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ORIGINAL ARTICLES.

I.—Some Notes on the Geology of the Bermuda Islands.

By R. Ashington Bullen, B.A. (Lond.), F.L.S., F.G.S.

(PLATES XVIII–XX.[1])

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I. General Introduction.

THE geology of the Bermuda group of islands has been so exhaustively treated by Professor Verrill, Dr. Alexander Agassiz, and Lieutenant (afterwards General) Nelson (in what will always be the classic memoir on the subject) that it may seem presumptuous for another description to appear. However, as there are

[1] Plates XXI–III will appear in October with Part II of text.

some new facts to record, and nothing has yet appeared in the Geological Magazine on the geology of Bermuda, a paper may be not altogether out of place.

In February last, when I told him of my intention to visit Bermuda, our veteran authority on the physics of the earth's crust, the Rev. Osmond Fisher, wrote: "The Bermudas are, I think, entirely volcanic. But I suppose quite anciently so, and that there are no cones, etc., now. There must be some interesting questions connected with them regarding changes of level of the ocean bed." Mr. Fisher was, of course, referring to the substratum of the islands. The evidence for the vulcanological origin of that proto-Bermudian land is threefold.

(*a*) *Charting.* There is the evidence of the Admiralty charts. In the narrative of the cruise of the *Challenger*[1] we find that the distance of 6 miles from the reef edge on the north-west of the group gave a sounding of 1,370 fathoms, and at 10 miles 2,100 fathoms. The slope off the North Rock is steeper than that off the north-east of Castle Harbour, e.g.:

Slope off North Rock 1,370 f. at 6 miles distance from reef edge.
,, Castle Harbour 1,250 f. at 8 miles from the 100 f. line.
,, south-west of Long Bar 1,250 f. at 5 miles from the 100 f. line.
,, north-east of East Ledge 1,000 f. only 2 miles from the 100 f. line, and 1,260 f. at 5½ miles from the 100 f. line.
,, south-west of the South-West Breaker 960 f. only 2 miles from the 100 f. line.
,, off the Argus Bank 1,370 f. at 10 miles from the 100 f. line.

This sudden deepening of the underlying mountain of which Bermuda is the summit, with two submerged peaks called the Challenger and Argus Banks respectively to the south-west of Somerset, is in accordance with the steep slope of a volcano with three peaks. The present degraded Bermuda volcano has a height of about 15,000 feet, equal to Mont Blanc.

(*b*) *Magnetic Deflection.* General Lefroy, Governor in the seventies, found that his own observations did not agree with the Admiralty charts. Observations made by the *Challenger* Expedition showed a variation of 6° in various parts of the islands, ranging from 4° W. to 10° W., the smallest amount being found at a small islet under Gibb's Hill and the greatest at the point west of Clarence Cove. The disturbing cause is probably the existence of iron rocks within varying depths from the present surface.

(*c*) *Analogy.* The well-known volcanic character of the Madeiras, Azores, Canaries, and other islands and rocks in the Atlantic would argue a similar origin for the Bermuda group. The islands mentioned are of Tertiary date,[2] but it is impossible to state the date of the Bermudas under present evidence. Verrill correlates them with Martinique and the West Indian group. Speaking of the main mass and also of the Challenger and Argus Banks he says, "No doubt each of these peaks and craters when they were most active rose high

[1] Wyville Thomson, *Voyage of the "Challenger"*, vol. i, p. 105. Also A. Agassiz, *A Visit to the Bermudas in 1894*, pl. ii (q.v.).
[2] *Student's Lyell*, ed. Judd, p. 501.

above the level of the sea, like the volcano of Teneriffe, though not so large or so high. Perhaps more like Martinique, Dominica, and St. Lucia among the Antilles. The size was similar to some of the latter, and there may have been many eruptions as violent as the recent eruptions from Mount Pélé and from as lofty a crater. In fact, there must have been a great many eruptions to have built up such an immense cone from the bottom of the deep ocean . . . during the Jurassic period reefs of corals existed as far north as Middle Europe, and the climate in the latitude of Bermuda in the Cretaceous and Eocene was no doubt much warmer than at present. In any case, the final result of the erosion of the larger volcanic cone must have been to form submerged banks or shoals at a suitable depth for the abundant growth of corals, mollusks, etc.

"George's Banks and Nantucket shoals off Cape Cod maintain themselves in the face of most violent storms; although composed of only sand and gravel, their shallowest parts rise to within 25 or 30 feet of the sea-level. This indicates that the erosive power of the sea waves decreases very rapidly, even at such depths."[1]

It is popularly supposed that Harrington Sound, Bermuda, is the crater of a volcano, but the charted soundings give no support to this idea. What there is deep down beneath we have no way of determining, but the depths are consonant with the features of a submerged valley, and that is all that can be said.

It is due to the prescience of Nelson that the true character of the present Bermudian rocks is known. At least, I give this statement on the authority of Wyville Thomson[2] and A. Agassiz.[3] I have not found the actual statement by Nelson himself.

Whether the primary rocks (moulded on the Bermudian volcano), now deeply submerged, are of the nature of coral-reef structure, cannot at present be ascertained. But all the rocks that can be examined are of 'æolian formation', a description attributed to Nelson by Wyville Thomson and A. Agassiz.

II. The Prevailing Winds.

The peculiar form of the Bermudas and the greater height of the land on the southern side have been caused by the prevailing winds. Although there are breezes and even at times hurricanes from the north and north-east, the prevailing winds are from the south-westerly direction. This is evident from the fact that the sand-dunes are forming on the south side of the main island, e.g. at Tuckerstown, Elbow Bay, Warwick Long Bay, etc. Nelson says, "Bermuda is not subject to any regular wind; perhaps to the south-west more than to any other."[4]

[1] A. E. Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 55.

[2] *Voyage of the "Challenger"*, vol. i, p. 307.

[3] *A Visit to the Bermudas in 1894*, p. 221. "Captain Nelson was the first to call attention to the æolian character of the rocks of the Bahamas and Bermudas. This character *saute aux yeux* in every direction."

[4] "The Geology of the Bermudas": Trans. Geol. Soc., ser. II. vol. v, pt. i, p. 104.

Similar evidence of this fact is supplied by others. "The south-west wind, the prevailing one, is generally preferred by the natives, as the warmest in winter and the coolest in summer . . . in the winter months the weather is delightfully bracing, when the wind is northerly without being too boisterous."[1]

"The prevailing wind throughout the year is from the south-west. The northerly winds are comparatively dry, but those from the south are vapour-laden . . . 9 grains to the foot of air being the average maximum of dampness and 6½ the general average."[2]

The result is, and probably has been throughout the various stages of the existence of the Bermudas, that the highest land was always to be found along the south side of the islands and the lowest towards the north. A glance at the Map (Plate XVIII) will show the reason that the greater part of the old Bermudian land is below the waves. For a subsidence of a very small amount would suffice to bring the lands on the northern side within the disintegrating action of the ocean waves. The flats that form part of that submerged land are fairly level in their general surface and only a slight distance under water, sometimes only about a foot, as may be seen in the photograph of the Governor (General Lefroy) and others standing on the flats near the North Rock in 1875.[3]

Harrington Sound is almost landlocked, and the water in the deepest parts is from 10 to 12 fathoms. The main current runs out at Flatts Village, but a great deal more reaches the sea by underground passages, as may be seen at the west of Castle Harbour (Text-fig. 3), where a great body of salt water pours through the beach as the tide goes down. Harrington Sound was undoubtedly once a valley in Proto-Bermuda, and the present depth of its floor may be taken as a measure of the subsidence which the former land has undergone, with perhaps some other, slighter oscillations.

A Bermuda elevated this amount above the present mean level of the ocean would measure about 230 square miles, instead of 19½ as at present, which seems to be the closest measurement made. This land Verrill calls Pliocene Bermuda. It may contain rocks of an even earlier age at its base, but the higher points and ridges of land are still underlain by the hard base rock in which are to be found the caves for which the Walsingham district of Bermuda is famous. All the caves may not, however, be of this age. But it is difficult to see how this formation can be attributed to any more recent origin, since, for reasons which will be apparent later on, it precedes the red clay which must have been formed at a time of great rainfall, and may be placed in the Pleistocene period, or probably earlier.

III. The Principal Geological Formations.

The principal geological formations of Bermuda are four: (1) the Walsingham, (2) the Devonshire, (3) the Paget, and (4) the Recent. The names Walsingham, Devonshire, and Paget are taken from the names of the parishes in which the several formations can be best studied.

[1] A Field Officer, *Bermuda*, 1857, pp. 31–2.
[2] Nelmes' *Bermuda Guide*, p. 54.
[3] Verrill, op. cit., p. 117.

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1. Sand-dune anchored by sea-lavender.
2. Sand-dune anchored by indigo-berry.
Both from Warwick Long Bay, south shore.

(1) *The Walsingham Formation.* This is Verrill's proposed name for the older rocks that are in sight, and he has so named them from the fact that in the north-east of the main island, round Harrington Sound and Castle Harbour, is the best place to study these hard and more or less crystalline æolian limestones. The beds are essentially

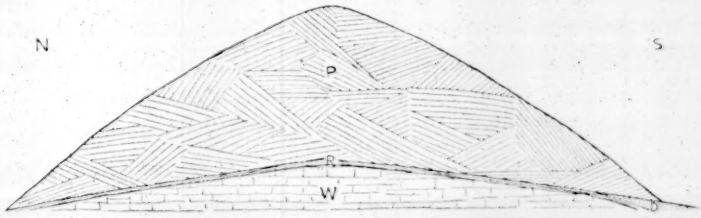

FIG. 1. Ideal section of Bermuda Formations. W, Walsingham formation (Pliocene); R, the red earth; D, Devonshire formation, Leda Clay (Glacial of Prestwich); P, the Paget, Post-Glacial and Recent formation.

of the same nature as the rest of the Bermudian limestones of later date, but by the infiltration of water supersaturated with calcic carbonate the æolian character is largely masked, the bedding-planes are nearly or altogether obliterated, and the hard limestone takes on a generally homogeneous appearance. But in this formation there are places where the shell sandstone of this age is friable and others where the shell-sand is found in pockets quite unconsolidated.

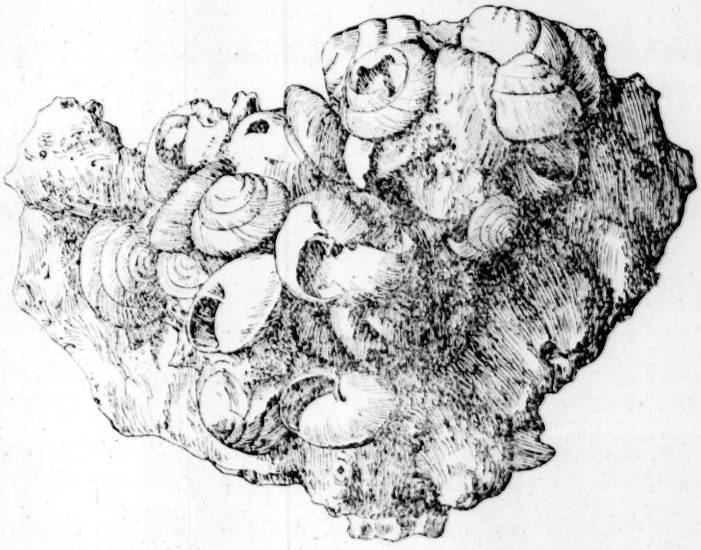

FIG. 2. Shell-conglomerate made up of a mass of shells of an extinct species of land-snail, *Poecilozonites Nelsoni*, etc. Drawn by G. M. Woodward from the collection brought from Bermuda and presented to the British Museum (Nat. Hist.) by Major Peile.

Although the Walsingham Beds are best studied in the north-east district they are not confined to it. Admiral's Cave at Spanish Point is in this formation, for in it is to be found the extinct endemic species of land mollusc, *Poecilozonites Nelsoni* (Bland), Pils., which may be taken as the characteristic fossil of these beds. Major Peile has added a fine series of this and other fossil and sub-fossil Zonitidæ to the British Museum, together with marine fossils from the higher Devonshire Series of Bermuda.

Much of the rock of this period, however, has no distinguishing fossil. The *P. Nelsoni* would only be found where the habitat had been congenial to it. There were spots where it flourished under favourable conditions of food-plant, shelter, and other advantages, just as to-day in places such as the blown sands of Cornwall, Norfolk,

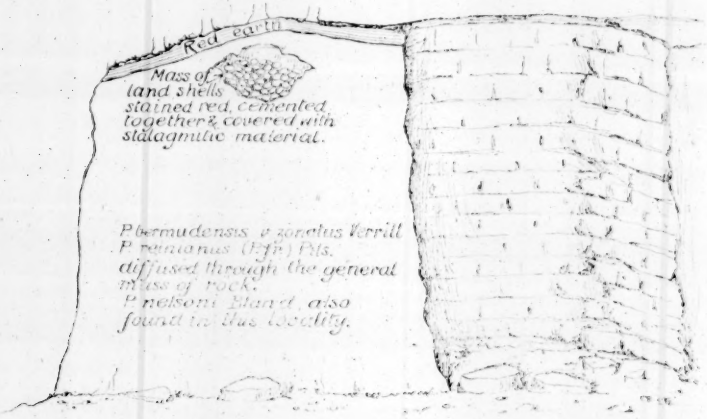
Red earth
Mass of land shells stained red, cemented together & covered with stalagmitic material.
P. bermudensis, P. zonulus Verrill
P. reinianus (Dkr.) Pils.
diffused through the general mass of rock.
P. nelsoni Bland, also found in this locality.

FIG. 3. Diagram sketch of cliff, west shore of Castle Harbour, to show deposit of land-shells. [No photograph was possible under the conditions of distance and sunlight available.] Surface covered with jungle of Bermuda juniper, sage, and ipecacuanha, festooned and overgrown with Cape jessamine. Sea-water discharges through the beach below from hidden caves draining Harrington Sound. The district is honeycombed with caves. On the right is a large quarry of hard crystalline limestone (Walsingham formation).

Brittany, Mallorca, and Spain land mollusca are abundant in some places, and for no readily ascertainable reason are absent under what appear to be identical conditions in others. The abundance of *P. Nelsoni* and its companion species, *Bermudensis*, *Reinianus*, *circumfirmatus*, which outlasted it, points to an abundant rainfall far greater than that which now obtains in these islands.

On the west shore of Castle Harbour, on Mr. Peniston's land, there occurs a cliff of hard Walsingham limestone, which contains scattered through its mass abundant specimens of various Helicidæ, and in a small cave or pocket, about 16 feet above the shore and quite unreachable without a ladder, a mass of the same shells is conglomerated together with a calcareous cement of stalagmitic character.

These shells are light in weight, bleached, brittle, and have lost their animal membrane seemingly, and are adherent slightly to the tongue. The caves owe their existence to the abundant rainfall during Pliocene and later times, and have been formed by solution and by underground streams very much as the caves of the Causse district in France and those of Derbyshire have been dissolved out. It will be seen in the later part of this paper that the sea can have had little or no part in their causation except where the caves are situated on the shore, and in this case they have apparently only been irrupted, not formed, by the sea. The sea, as at Cathedral Rocks in Somerset parish, has rather destroyed and opened out cavities which were previously existing.

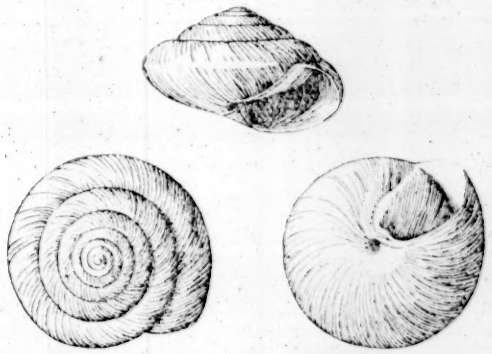

FIG. 4. *Pæcilozonites Bermudensis*, var. *zonatus*, Verrill, from Castle Harbour Cliff. (Specimens from the later Paget rock formation; in the brightness of their colour and state of preservation are comparable to the *H. memoralis* of the Abbott Fissure at Ightham.) Drawn by G. M. Woodward.

It is said that for crystallization to take place there must not only be abundance of water supersaturated with calcic carbonate, but also rapid evaporation. This is probably true. But it is probably true also that, given efficient drainage, the matter in solution is deposited by the arrest of the running and percolating water, and that the calcic material may be precipitated quite as much by such arrest as by evaporation. It would be difficult otherwise to account for the thick deposits in the immense caves of Kentucky, Belgium, Mallorca, and elsewhere. For though evaporation can never be very great in the cool depths of such caves, the enormous deposition of stalactite and stalagmite is a fact everywhere patent in them.

At the top of the Walsingham formation there is a layer of red soil (see Text-fig. 1). This is due seemingly to the solution of the overlying shell-sand, just as the red clay (on the Chalk plateau) is partly due to the dissolution of the Chalk. In Bermuda the red clay must be wholly a dissolution product. The shell-sand which makes up the great mass of these æolian sands is not all soluble, and some of the material is left after the calcic material has been dissolved out. This residuum is taken to represent the remains of 150 feet of shell-sand for every foot

of its depth. Taking the average depth as 8 inches, this would give a removal of 100 feet of denuded strata from above the Walsingham formation. However, this is not all the waste. This dissolving in all probability took place mostly in Pliocene and partly in early Pleistocene times. Some solution is, of course, also still going on slowly. But the total denudation of this period is probably for the average of 18 inches of soil (red) at least 225 feet. The proportions of the red soil vary greatly according to the source of the sample analysed. The shell-sand contains from ·005 of earthy impurities upwards (insignificant as this seems it amounts to 5 tons of every thousand dissolved), and the analyses show calcic carbonate, as well as oxide and sulphate, magnesic carbonate, alumina, ferric oxide, sand, insoluble clay, silica potash, soda, carbon dioxide, etc.[1]

Dr. A. Russel Wallace thought that the red earth was produced from pumice thrown up by the sea. But, as Agassiz says, "Although I examined the beaches of the south shore many times, I never succeeded in finding a single piece of pumice. Red earth is abundant, both in the Bahamas and Bermudas, in localities to which drift pumice could not have access."[2] These red layers, from 2 to 10 inches thick, interstratified with the limestone of the Walsingham period, are clearly seen in several sections. The 8 inch upper layer becomes a line of demarcation as good as we are likely to obtain. This red soil was proved at Prospect Hill, in a military boring at a depth of 130 feet and at 65 feet above O.D.[3] As the same red clay descends nearly to the shore at Hamilton, an ideal section of the underlying Walsingham rock would be of a saddle shape, taking the direction of north and south, and the Devonshire and Paget formations would lie against or above it respectively. The Walsingham formation probably underlies the whole length of the islands and reaches its greatest height somewhere about Prospect Hill or Sears Hill, though it is about 50 feet or so below O.D. at and near Ireland Island.

On Mr. Richard Kempe's land in Warwick parish the underlying rock is of a hard crystalline nature and the soil is red but not very deep, and on the northern slope, about the 50 feet contour, the limestone is of a crystalline nature, with veins of fine calcitic crystals resembling the calcite of the Oreston Cave, near Plymouth. Everywhere I examined the same fact holds good, the red soil is underlain by hard rock.

Verrill considers that most of the serpuline atolls and outlying flat reefs of the south coast are composed of the hard limestones of the Walsingham period, although the characteristic extinct fossil land-snails have as yet not been found in these reefs.[4]

(2) *The Devonshire Formation.* There has been much discussion about the position and date of the beach rock. Some of the older and more elevated of the beach rocks indicate that they were formed in

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, pp. 490, 493.

[2] A. Agassiz, op. cit., p. 236.

[3] The thickness was 8 inches according to Goldie, Lecture on the Geological Formation of Bermuda, 1893, pp. 14, 15.

[4] Op. cit., p. 73.

a period of depression. Some of these now lie 12 or 16 feet above the sea, and by the fine character of the materials and good condition of the shells appear to have been formed in quiet waters and not tossed up by hurricanes. These delicate shells and Foraminifera (such as are found at depths of from 3 to 5 fathoms) indicate that after deposition the beds containing them have been raised 20 to 30 feet or more above their previous level.[1]

As these deposits are well developed at Devonshire Bay, Verrill has proposed the name of Devonshire Beds for them. They contain some twenty species of Pelecypoda and thirty-one of Gasteropoda, all marine.[2] At Hungry Bay delicate shells of Mollusca—*Cæcum*, etc.—were found entire in the finer layers of rock.

Verrill gives the following species as not certainly known to be living in Bermudian waters at the present time: *Strombus accipitrinus*, Lam.; *Fasciolaria distans*, Lam.; *Scala* sp.; *Venus*, a large lamellose species; *Turbo* (*Livona*) *pica* (L.); *Callista* (*? maculata*); *Phacoides Pennsylvanicus*, var. *Somersensis*, Verrill; *Balanus*, a large massive species; *? Mycetophyllia Lamarckiana*, Ed. & Haime; *? Maeandra areolata* (L.), Oken; *Melitta testudinata* (Klein). All the beach rocks are not of this age—which Verrill places about the Champlain or Post-Glacial Period—but some are doubtless being formed still and also destroyed by storms that occasionally occur with great violence. (The Champlain or Leda Clay period belongs to the Glacial Period according to Prestwich.)

Agassiz, however, groups all these beach rocks as of recent origin and formed since the islands attained their present level. His own observation leads him to look upon the beach rock of the Bermudas as consisting mainly of the larger and heavier æolian materials, which either have not been carried so far or blown to so great a height as the lighter æolian sand.[3] He considers that all the beach rock has been formed from recent shell-sand by the hardening action of salt water and rain. In England such beach rock is forming on the sea-shore near the cliffs on the west of Harlyn Bay by the infiltration of rain-water through the blown shell-sand cliffs to the beach. A shelf some 40 yards long and 2 or 3 yards wide is thus in process of consolidating. Some of the Bermudian beach rock may have been formed in this way, but Verrill seems to have made out a very good case for the distinct character and intermediate date of some of these marine beach beds as being of a precedent origin to the formation we have next to consider.

These Devonshire Beds would lie unconformably against and not overlie the higher parts of the earlier Pliocene Walsingham Beds, if the fact is that these latter form a spine for the whole length of the islands, since we have seen that the latter beds are of a height of 65 feet above O.D. at Prospect Hill and no doubt elsewhere, whereas the submergence suggested by Verrill may be put at only 14 to 18 feet.

(3) *The Paget Formation.* The last series of rocks overlies the Devonshire Series, and is generally composed of consolidated soft

[1] Verrill, "The Bermuda Islands: Geology": Trans. Conn. Acad. Arts Sci., vol. xii, p. 189.

[2] Op. cit., pp. 76, 190.

[3] A. Agassiz, op. cit., p. 225.

shell sandstone of æolian origin. There are about 150 feet of this rock probably, and being the last of the Bermudian rocks it has not suffered so great an amount of denudation as that to which the Walsingham Series has been subjected. The Paget rock forms the principal source of the building and roofing-stone of the islands, and is cut in the quarries with a peculiarly-shaped saw into blocks of suitable size and thickness for building and roofing respectively. The rock is porous in texture and readily admits rain. It consequently has to be whitewashed, and then may be said to be sufficiently impervious to rain to form a suitable building material. Houses so built are not, however, altogether dry. It can easily be seen that the porosity of this rock allows the rain to sink away and prevents the formation of surface streams. Most of the wells are brackish, since the porosity of the rock allows the sea-water to percolate below O.D. Warwick Pond, e.g., seems to be in direct communication with the sea, although far inland.

It is in this series that the shells of *Turbo* (*Livona*) *pica* are found. They also occur in the Walsingham Series. These have been carried to various levels by the hermit-crab *Cenobita diogenes* (L.), whose fossil remains have been found in them. There is some doubt whether these fossil turbinoid shells[1] have not been collected from more modern sand-dunes, having fallen out of the more ancient rocks to the beach,[2] but this is unimportant since the cause of their being found at various levels has been sufficiently demonstrated. Abundant burrows of land crabs are to be seen on the south shore at Astwood's Bay, Kempe's Bay, and elsewhere.

In the museum at Hamilton is to be seen the head and a part sawn off from the carapace of a leather-back turtle, *Sphargis coriacea* (L.), Gray; the locality is not stated, but from the condition of the remains (which were entire when found) it is most probably from the Paget formation. It would have been from 900 to 1,000 lb. in weight.

From the Paget Rock near Hamilton have also been obtained fossil eggs of some indeterminate sea birds (possibly some also of turtle's); one from Devonshire parish was found at a depth of 4 feet, another from Smith's parish at 15 feet, and one, in March, 1896, at 28 feet (loc. incert.) below the surface. They were sawn through in the operation of quarrying, but their outline is well preserved, and in one case the inside is filled with shell-sand, having evidently been broken by some accident at the time of laying or shortly afterwards. One turtle and at least one bird seem to have been overwhelmed by a sand-fall, but whether these belong to this or the Walsingham Series, or to what species they are to be credited, there is no evidence to show.[3]

[1] Nelson, "The Geology of the Bermudas": Trans. Geol. Soc., ser. II, vol. v, pt. i, p. 112, says, "It seemed difficult at first to account for these large shells (*Turbo pica*) being found on heights where from their weight it was impossible to suppose they had been carried by the wind; but a solution may be found in the habits of the soldier-crab, which on more than one occasion I have seen running about in these shells." See Verrill, "Geology of Bermuda," p. 197, with picture from life of a land hermit-crab in a fossil shell of *Livona pica*.

[2] I have one specimen of *Livona pica*, found on the present beach, which has evidently weathered out of the Paget Rock and fallen to the beach.

[3] Verrill, op. cit., p. 195.

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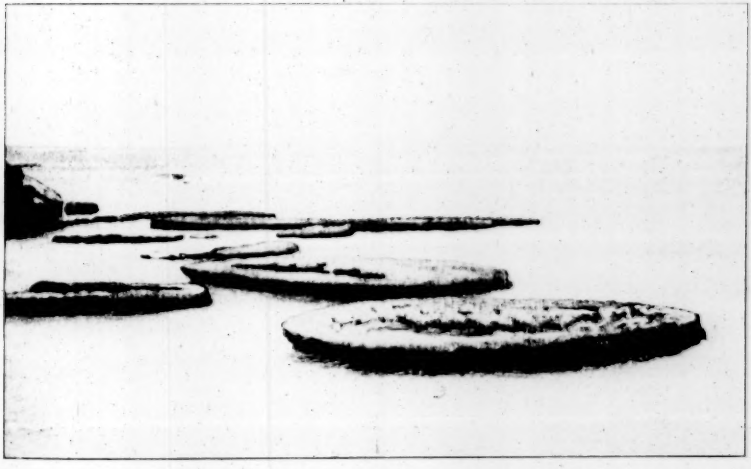

1. Recent landslip (Paget formation), Kempe's Bay, Bermuda.
2. Serpuline atolls, south shore, Bermuda.

There are also fossil remains of the shearwater (*Puffinus obscurus*, Hurdis & Reid; *Audubon*i, Finsch) from Smith's parish. Mr. L. L. Mowbray, the curator, has mounted the sternum found alongside of the recent skeleton of the shearwater, with whose measurements the fossil agrees.

EXPLANATION OF PLATES.

PLATE XVIII.

Map of Bermuda, showing principal points touched on in the paper. Drawn by Mrs. Ballen.

PLATE XIX.

Fig. 1. Sand-dune 'anchored' by sea-lavender (*Tournefortia gnaphaloides*, R. B.).

,, 2. Sand-dune 'anchored' by indigo-berry (*Randia aculeata*, L.).

Both Figs. 1 and 2 from Warwick Long Bay, south shore.

PLATE XX.

,, 1. Recent landslip, Paget formation, Kempe's Bay, Warwick parish, south shore.

,, 2. Serpuline 'atolls', south shore.

(*To be concluded in the October Number.*)

II.—A Carboniferous Arachnid from Lancashire.

By E. Leonard Gill, M.Sc., Curator of the Hancock Museum, Newcastle-upon-Tyne.

THE specimen represented in the accompanying figure was obtained from the Coal-measures of Westhoughton, near Bolton, Lancashire, and has been kindly lent to me by Mr. Thos. Midgley, of the Chadwick Museum, Bolton. It is the nearly complete abdomen (opisthosoma) of an arachnid of the order Anthracomarti. The concavity of the outer margins of the pleural laminæ, producing the scalloped outline shown in the figure, indicates at once that the specimen must be assigned to the family Brachypygidæ[1]; but it is less obvious to what genus it may belong. Mr. Pocock's monograph (see preceding footnote) gives only two genera as known in the family, namely *Brachypyge*, Woodward, and *Maiocercus*, Pocock. Comparison between these two is rendered difficult by the fact that of the former only the dorsal surface is known, of the latter only the ventral; of neither has any part but the opisthosoma yet been recognized. Accordingly, in differentiating his genus *Maiocercus* from *Brachypyge*, Mr. Pocock[2] was compelled to fall back upon two characters—the general shape of the opisthosoma and the angles made by the anterior pleural laminæ. *Brachypyge* is defined as having the "opisthosoma much longer than wide; pleural laminæ of the second and third pleura-bearing terga inclined slightly backwards"; *Maiocercus* as having the "opisthosoma much wider than long; pleural laminæ of the first, second, third, and fourth sterna inclined slightly forwards".

These definitions fail when applied to the present specimen, for though on the whole the inclinations of the pleural laminæ agree with

[1] See R. I. Pocock, "Terrestrial Carboniferous Arachnida of Great Britain": Palæontographical Society, vol. lxiv, p. 58, 1911.

[2] Loc. cit., p. 59.

those attributed to *Maiocercus*, the other criterion, the proportion of length to breadth, does not help us, since the length and breadth are as nearly as possible equal. Nevertheless I am disposed on general grounds to refer this specimen, with very little hesitation, to *Maiocercus*. If I am justified in doing so, the specimen not only necessitates a slight modification in the definition of the genus, but adds largely to our knowledge of it. It is the dorsal surface that is shown, and up to the present only the ventral surface of *Maiocercus* has been described.

Since the dorsal surface of the opisthosoma of *Brachypyge* is well known (from Dr. Woodward's figure, copied in Mr. Pocock's monograph), direct comparison is possible between it and the present specimen. Considerable differences are obvious. The most important are those relating to the axial parts of the tergal plates, which are proportionately much wider than in *Brachypyge*; whilst the eighth tergum is not fused, as in *Brachypyge*, with the inner parts of its

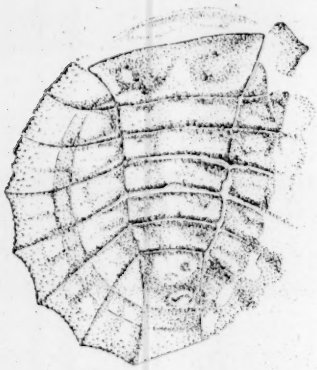

FIG. 1. *Maiocercus orbicularis*, sp. nov. Coal-measures, Westhoughton, near Bolton (dorsal surface of opisthosoma).

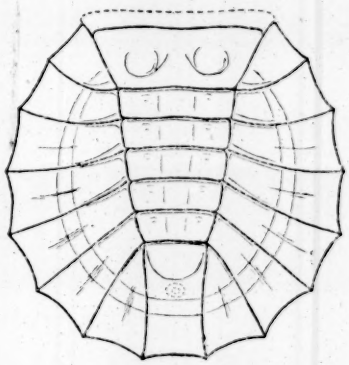

FIG. 2. *Maiocercus orbicularis*, sp. nov. (restored outline of opisthosoma).—Both figures drawn three times nat. size.

pleural laminæ. The various systems of sutures separating and subdividing the laminæ correspond in a general way in the two forms, but in *Brachypyge* they are apparently much more strongly marked than in this specimen from Westhoughton. A similar direct comparison with *Maiocercus*, of which only the ventral aspect is known, is naturally out of the question, and all that can be said is that the Westhoughton specimen presents us with a dorsal surface which is much what we should expect to find on the back of a *Maiocercus*. Incidentally it seems to confirm Mr. Pocock's surmise[1] that *Maiocercus* is in some respects more nearly related to *Anthracomartus* than to *Brachypyge*.

A few points of detail call for mention. The first somite is missing; the dotted outline in Fig. 2 is intended to indicate its absence rather than its probable form. The ill-defined plate lying in front of the

[1] "Terrestrial Carboniferous Arachnida of Great Britain": Palæontographical Society, vol. lxiv. p. 60.

second somite may possibly be a portion of the first, or the first in some displaced position; it is seen much better on the piece of shale bearing the impression than on the one bearing the fossil itself. Some hint as to the shape of the first tergum is perhaps given by the pleural laminæ of the second; these extend forward beyond the second tergum and their inner edges continue to diverge, as though to accommodate a first tergum which carried still further the spreading form of the second.

The succeeding somites, the second to the eighth, are well defined. The second is much larger than the rest; the third to the seventh are nearly equal in length and show a regular decrease in breadth; the eighth is narrower and longer than any of the others. The second tergum bears a pair of large but indistinct tubercles, and there are traces of smaller and still less defined tubercles occurring in pairs, one on each side, on the succeeding somites. A low, rounded ridge runs down the centre of the terga, originating in the triangular space between the tubercles on the second tergum. A rounded swelling occupies the anterior part of the eighth somite, and may have been present in life; it fits in well with the converging lines formed by the lateral edges of the preceding terga. Behind this swelling, and a little to one side, there is an oval papilla, grooved in the middle, which is possibly the imprint of a crushed anal plate lying below. The integument is preserved over the greater part of the fossil, and is everywhere finely granulated. It is missing, however, from the outer parts of the pleural laminæ (with the exception of the foremost lamina on the right), and these show towards their outer edge a rather coarser granulation and pitting. The original drawing of *Maiocercus celticus*[1] indicates a similar pitting on the underside of the laminæ. The concavity of the outer margins of the laminæ is not uniform. It is well marked in those of the fifth, sixth, seventh, and eighth somites, but not in those of the second, third, and fourth. In the case of these three anterior laminæ, however, I am inclined to attribute the shape of the margin to distortion. The whole front of the opisthosoma is bent somewhat backwards on the left side, and the edges of the anterior laminæ on that side are notched here and there in a way that suggests crumpling. In the restored outline I have assumed that these laminæ, if straightened out, would show nearly as much concavity of margin as those that succeed them.

The length of the opisthosoma is about 15 mm. and its breadth about the same. The opisthosoma of *Maiocercus celticus* appears to be of much the same breadth as that of the Westhoughton specimen,[2] but its length is only about 11·5 mm. This difference in general proportions presumably indicates specific distinctness; it is greater than can be accounted for with any probability by variability or by conditions of fossilization. Specific names have little value in such a case, but it might cause more trouble to leave the fossil unnamed than to add one

[1] By F. T. Howard & T. H. Thomas, Trans. Cardiff Nat. Soc., vol. xxviii, plate facing p. 53, 1896.

[2] I have estimated the dimensions of *Maiocercus celticus* from Messrs. Howard and Thomas's figure (see last footnote), which they state to be six times the natural size. The figure on p. 60 of Mr. Pocock's monograph must have been described as of natural size by mistake.

more name to the nomenclature of the group. I would propose, therefore, that it should be known for the present as *Maiocercus orbicularis*.

If the specimen is rightly ascribed to *Maiocercus*, the definition of the genus must be modified so as to cover an "opisthosoma wider than long or about as wide". The other point of Mr. Pocock's diagnosis, the forward inclination of the pleural laminæ, is not affected. Further diagnostic points, which may now be added regarding the dorsal surface, have already been indicated. It may be remarked that though the Westhoughton specimen approaches *Anthracomartus* in the general form and proportions of its tergal plates, it suggests affinities with *Brachypyge* in one or two respects apart from the concave borders of the laminæ. As already pointed out, there is some hint of a first tergum still wider than the second, as it is in *Brachypyge* but not in *Anthracomartus*. A less speculative point of resemblance to *Brachypyge* (and again of divergence from *Anthracomartus*) is the double line of suture crossing the pleural laminæ. On the whole, then, the new specimen, while it necessitates a slight change in the definition of the genus, not only further demonstrates the distinctness of *Maiocercus*, but tends also to strengthen its claim to stand with *Brachypyge* in a family apart from the other Anthracomarti.

III.—On a new species of *Desmoceras* from the Chalk Rock of Buckinghamshire.[1]

By A. H. Noble, B.A., F.G.S.

Whilst engaged on the new Geological Survey in the neighbourhood of Marlow, I had the good fortune to come across an exposure of Chalk Rock yielding an exceptionally rich fauna, including a single specimen of an ammonite which appeared to be new to science. This ammonite was therefore shown to Dr. Kitchin, Mr. Crick, Dr. Rowe, and Mr. H. Woods, none of whom had seen the species before or could recognize it as a form already described. The discovery of new Cephalopods from the Chalk is now so rare that it seems worth while to draw attention to this, although the whole of the accompanying fossils have not yet been identified.

The specimen is preserved in the form of an internal cast in very hard glauconitic chalk. It shows well the sutures, but is entirely septate, no part of the body-chamber being present. When complete it must have measured at least 55 mm. in greatest diameter and possibly more. In the earlier formed part of the outermost whorl the siphuncle is exposed to view as a narrow tube of dark-brown colour with glossy surface; in the later portions of the whorl the form of the tube is not preserved, but its course is well shown.

Desmoceras marlowense, sp. nov. (Figs. 1 and 2.)

The shell is discoidal, with the whorls increasing slowly, the height of the outer whorl being about two-fifths of the diameter of the shell. The inclusion is about one-half. The umbilicus is moderately wide

[1] Communicated by permission of the Director of the Geological Survey.

and shallow, its diameter (measured from the spiral suture) being rather more than one-third of the diameter of the shell. The peripheral area is broadly convex, sloping more steeply down to the point of maximum breadth of the whorl in cross-section, which is situated at about two-fifths of the radial diameter measured from the umbilical margin. The umbilical zone is fairly large, sloping steeply down to the spiral suture.

There is a series of constrictions, numbering about eight on a whorl. The course of these is straight up to the siphuncle, where the ligation becomes directed very slightly forward. No ribbing is visible on the cast, but there are some traces of nodular swellings, each one situated posteriorly to a constriction at the outer limit of the umbilical slope.

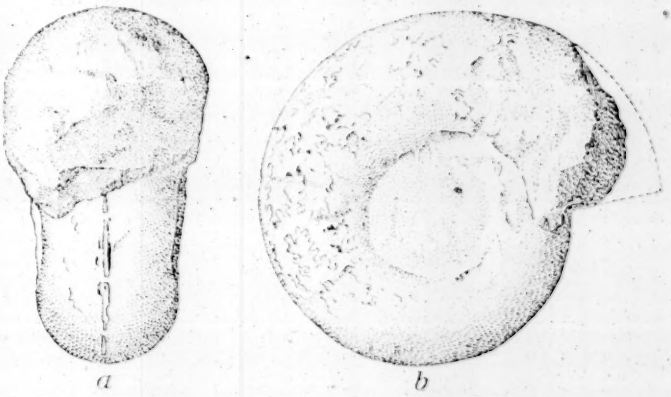

FIG. 1. *Desmoceras marlowense*, sp. nov. *a*, front view; *b*, lateral aspect. Chalk Rock: Marlow, Buckinghamshire. Both nat. size.

The suture-line is well seen on several parts of the specimen, and can be traced from the siphonal line as far as the second lateral lobe. The external saddle is divided into two parts by a fairly deep lobe, that part nearer the siphuncle being slightly greater than the other part.

The first lateral saddle is about as high as the external saddle, but is simpler. The first lateral lobe is trifid and of the same length as the ventral or siphonal lobe. The second lateral lobe is similar to the first, but shorter and simpler.

Dimensions.	mm.
Greatest diameter	51
Height of outer whorl	21
Thickness of outer whorl in cross-section	25
Width of umbilicus	19

Locality and Horizon.—The specimen was found in a small pit about one-quarter of a mile E.N.E. from Blount's Farm, Great Marlow. Here the whole of the Chalk Rock is exposed, and a very rich fauna was obtained from a band which occurs just above the green nodular band about 2 feet from the top of the Chalk Rock zone of *Holaster planus*.

The specimen is preserved in the Museum of Practical Geology, registered 25456.

Remarks.—It must be mentioned that the appearance of rapid modification to a less involute state, presented by the last-formed part of the last whorl as seen in Fig. 1*b*, is entirely due to the imperfect preservation of that part of the specimen. There also the peripheral region of the cast has become broken away, and is restored in the Figure by a dotted outline. It is not possible to say how much of the septate part of the specimen is missing, and the length that might have been attained by the body-chamber is, of course, also unknown. Although uncoiled or partially uncoiled ammonitoids, such as *Heteroceras*, *Scaphites*, *Crioceras*, and *Baculites*, are fairly common in the Chalk Rock, few species which are unmodified in this manner have been recorded. Mr. H. Woods has described two, *Pachydiscus peramplus* and *Prionocyclus neptuni*,[1] and Messrs. Chatwin & Withers have recently identified a new species, *Puzosia curvatisulcata*, from the Waterworks Quarry, Marlow.[2]

FIG. 2. *Desmoceras marlowense*, sp. nov. Part of suture-line. ×2.

The specimen here described is referred to the genus *Desmoceras* principally on the evidence of the suture-line, which is well shown. The lobes are trifid, the first lateral being of about the same length as the ventral. The saddles are similar to one another, and each one is divided into two parts. A certain degree of similarity is shown to *Desmoceras pyrenaïcum*, de Grossouvre, from the Middle Senonian (Santonian) of Sougraignes, Aude.[3] The suture-line is almost identical in the two forms, and they are alike in the presence of constrictions. These, however, are more oblique in their course and take a stronger forward bend on the peripheral area in the French species.

D. pyrenaïcum is considerably more involute, and the outline of the whorl also differs; the peripheral zone is more convex and the umbilical zone less steep than in the English form.

My best thanks are due to Dr. Kitchin and Mr. Clement Reid for their kind assistance in the preparation of this paper.

[1] H. Woods, "The Mollusca of the Chalk Rock," Part I: Q.J.G.S., vol. lii, pp. 77, 79, 1896.

[2] C. P. Chatwin & T. H. Withers, "Contribution to the Fauna of the Chalk Rock": GEOL. MAG., Dec. V, Vol. VI, p. 66, 1909.

[3] A. de Grossouvre, "Recherches sur la Craie Supérieure," 2e Partie: Mém. Carte Géol. France, p. 168, pl. xxv, fig. 2, and pl. xxxvii, fig. 9, 1893.

IV.—On some Freshwater Mollusca from the Pliocene Deposits of East Anglia.

By A. S. Kennard, F.G.S., and B. B. Woodward, F.L.S., etc.

NON-MARINE Mollusca are extremely rare in the Pliocene deposits of this country, which fact must always be a matter of regret to the Palæontologist, since they are of the utmost importance in connexion with the origin of our present fauna. Unfortunately, in addition to their rarity, they are often decorticated or fragmentary, whence no doubt the differences in opinion as to their correct determination. A re-examination of all the available material has convinced us that there is still much to be done before it will be possible to reach finality. In these matters so much depends on one's standpoint. If one starts with the preconceived idea that the Pliocene shells must be identical with the recent forms, it is easy enough to identify them, even if one has to go to Japan or Greenland to find its present habitat. If, on the other hand, one considers it better to study carefully the results of recent work on other branches of the fauna, it is obvious that different results will be arrived at. Hence we are quite prepared for any differences of opinion as to the correctness of our views or the wisdom of creating four new species, as we now venture to do.

1. Limnæa Harmeri, n.sp.

Shell elongate, oblong-conic, thin; spire elevated, slightly turreted; apex acute; whorls 6 (or 6½ ?), convex, smooth; suture fairly deep, oval, entire; inner lip reflected, but seemingly not spread on the columella and does not conceal the umbilical chink. Height 15, breadth 7 mm.; aperture, length 6, breadth 4 mm. Pliocene—Norwich Crag (Icenian): Bramerton, Norwich. Type in the Norwich Museum.

Limnæa Harmeri, n.sp. (The scale represents millimetres.)

This species is only represented by a single example, but there can be no doubt as to its specific distinctness. It may be distinguished from *L. tenuis*, S. Woodward (*Geology of Norfolk*, tab. 3, fig. 30) (=*L. palustris*, Müll., of S. V. Wood, *L. palustris*, Müll., of Kennard and Woodward, *L. elodes*, Say, of S. V. Wood, and *L. pingelii*, Möll., of S. V. Wood), by its more pronounced suture, more convex whorls, and markedly oval mouth. Though bearing a superficial resemblance to some forms of *L. palustris*, Müll., in all probability it has no affinity with it.

We have great pleasure in associating with this species the name of Mr. F. W. Harmer, in recognition of his lifelong work among the later deposits of East Anglia.

2. Limnæa Butleyensis, n.sp.

Shell small, ovate-conic, thin; spire elevated, somewhat turreted; apex acute; whorls 5½, convex; suture deep; aperture ovate, slightly contracted on the inner side; umbilicus nearly closed. Pliocene—Red Crag (Butleyian): Butley, Hollesley, Suffolk. Norwich Crag (Icenian): Bramerton, Thorpe, Norfolk. Type in our collection.

This is the *L. truncatula*, Müll. (?), of S. V. Wood (*Crag Moll.*, vol. i, p. 8, tab. 1, fig. 8*a*), the *L. Holbollii*, Möll., of S. V. Wood (op. cit., supp., p. 3), and the *L. truncatula*, Müll. (*pars*), of Kennard & Woodward (Proc. Malac. Soc., vol. iii, p. 197).

This species may be distinguished from the polymorphic *L. truncatula* in being larger, in having the mouth more oval, whilst the whorls increase much more regularly. It is doubtful if *L. Butleyensis* has any real affinity with *L. truncatula*, nor can it be looked upon as a possible ancestor of that species. The largest example we have seen measures 12 mm. in height and 6 mm. in breadth.

The measurements of the type-specimen are: height 10, breadth 5 mm.; length of aperture 5, breadth 3·5 mm.

3. Limnæa Woodi, n.sp.

Shell small, ovate-conic, thin; spire elevated, little more than half the total length, turreted; apex rather acute; whorls 4½, somewhat swollen; suture deep; aperture ovate, slightly contracted on the inner side; umbilicus nearly closed; body-whorl striated parallel with the aperture. Height 6, breadth 4 mm.; aperture, length 3·7, breadth 2·5 mm. Pliocene—Red Crag (Butleyian): Butley, Suffolk. Norwich Crag (Icenian): Bramerton, Norfolk.

This is the *L. truncatula* (?), Müll., var. B, of S. V. Wood (*Crag Moll.*, vol. i, p. 8, tab. 1, fig. 8*b*). It may be distinguished from *L. Butleyensis* by its much smaller size, shorter spire, and relatively larger body-whorl. It is apparently a rare form, for we have only seen one example; this, which is in our collection, and is from Butley, we take as the type. There can, however, be no doubt that the example figured by S. V. Wood from Bramerton, which we have been unable to trace, is identical.

4. Planorbis præcursor, n.sp.

Shell sinistral, discoidal, smooth; spire depressed, nearly flat beneath; margin slightly carinated; aperture simple, lunate, subquadrate, oblique; outer lip thin, inner lip slightly spreading over the body-whorl. Pliocene—Red Crag (Butleyian): Butley, Hollesley, Norwich Crag (Icenian): Bramerton, Southwold, Bulcamp, Coltishall.

This is the *P. complanatus*, Linn., of S. V. Wood (*Crag Moll.*, vol. i, p. 9, tab. 1, figs. 10*a–c*) and the *P. marginatus*, Drap., of Kennard & Woodward (op. cit., p. 197). It bears a superficial resemblance to the recent shell which is now generally known as *P. umbilicatus*, Müll., but it may be easily distinguished from that species. It is much smaller, the rate of increase of the whorls is

much less, the carination is not so prominent, and it is a perfectly smooth shell, lacking the characteristic striæ of *P. umbilicatus*. The example in our collection, which we take as the type, measures 12 × 2 mm. It is not improbable that this Crag shell is the ancestor of the recent form, but better examples of *P. umbilicatus* (Müll.) from the Forest Bed (Cromerian) are needed before one can state definitely whether this view be correct.

V.—Palæontological Notes from the Manchester Museum.

Archæocidaris in the Middle Coal-measures of Lancashire; with Notes on other Species.

By J. Wilfrid Jackson, F.G.S., Assistant Keeper, Manchester Museum.

In the course of working through the large collection of Coal-measure fossils in the Manchester Museum I have recently discovered a number of interesting, and hitherto unrecorded, forms from the well-known 'Marine Band' in the Middle Coal-measures of Ashton-under-Lyne. The most interesting of these additions is undoubtedly *Archæocidaris*, a genus which is not at all common in the Coal-measures of this country, though fairly abundant in North America. Hitherto it has only been recorded from the North and South Staffordshire Coal-fields; its discovery, therefore, at Ashton constitutes the third record for the British Isles.

With the possible exception of the two forms of *Orthoceras*, which require further study, all the species mentioned below have been recorded from the Marine Band below the Gin Mine Coal, North Staffordshire Coal-field, and their occurrence in the Marine Band at Ashton, Lancashire, affords further confirmatory evidence of the correlation of these two bands.

Other species already recorded from the Marine Band at Ashton and Dukinfield are *Ctenodonta lævirostris*, *Pseudamusium fibrillosum*, *Pterinopecten papyraceus*, and *Listracanthus*, specimens of which are in the Manchester Museum.

Echinodermata.

Archæocidaris sp. This is represented by a fragment of the basal portion of a spine, its length being about 10 mm. Immediately above it is the cast of some 15 mm. more of the same spine, and just below is the impression of the basal end. The spine is very like that figured from below the Gin Mine Coal, North Staffordshire Coal-field,[1] and possesses similarly disposed spinules. The specimen forms part of the 'Wild Collection', and was obtained from the Marine Band (450 feet above the Great Mine Coal) at Ashton Moss Colliery.

Brachiopoda.

Orbiculoidea nitida (Phill.). After careful study I am unable to separate *Discina orbicularis*, Bolton,[2] recorded from the Ashton Moss Marine Band (Cairns Collection) and roof of the Bullion Coal, Carr Heys, Colne (Wild Collection), from dwarfed or immature examples

[1] Q.J.G.S., vol. lxi, p. 529, pl. xxxv, figs. 1, 1*a*, 1905.
[2] Manch. Memoirs, vol. xli, No. 6, pp. 2, 3, pl. v, figs. 1, 2, 1897.

of Phillips' species. It is true they are flatter than most examples, but this may be due to pressure. Specimens of *O. nitida* from Eccup, near Leeds (shale below third grit), agree with this form exactly. I have been unable to compare them with actual specimens from the North Staffordshire Coal-field, but from the illustrations in Dr. Hind's paper[1] the forms appear to be identical.

Lingula mytiloides, Sow. Several specimens of a *Lingula* (now in the Manchester Museum) were collected many years ago by Mr. R. Cairns at Ashton Moss Colliery. These were referred to by Mr. H. Bolton as *Lingula* sp. in his paper on the "Palæontology of the Lancashire Coal-measures".[2] A careful comparison with specimens of *L. mytiloides* from the Staffordshire Coal-field (over Moss Coal) and other places proves them to be that species.

Gasteropoda.

Loxonema acutum, de Kon. (?). In the Grundy Collection, recently acquired by this Museum, is the cast of a univalve, which, in all probability, is referable to this or some other species of *Loxonema*. It is 8 mm. in length and appears to consist of eight or nine apical whorls. Unfortunately no details can be made out owing to its bad state of preservation. The locality whence the specimen was obtained is the well-known Marine Band exposed on the bank of the River Tame at Dukinfield, its horizon being the same as that of *Archæocidaris*, etc.

Lamellibranchiata.

Posidoniella sulcata, Hind. Several specimens in the Wild Collection from Ashton Moss Colliery are referable to this species, Dr. Hind having kindly confirmed the identification of examples submitted to him. All the specimens are unfortunately very imperfect, but the ornament, consisting of concentric angular ridges, separated by fairly broad, concave sulci, agrees exactly with that of *P. sulcata*.

Dr. Hind states in his paper on the "Palæontology of the Marine Bands in the Coal-measures" (North Staffordshire)[3] that he is of opinion that he saw, several years ago, a specimen of *P. sulcata* from the Lancashire Coal-measures in the cabinet of the late Mr. Neild, of Oldham, but all attempts to trace the specimen have failed. He further adds, "Mr. H. Bolton[4] quotes *Posidonomya lateralis*, a synonym of *P. becheri*, as occurring in the Lower Coal-measures of Lancashire. Possibly he may have mistaken a specimen of my species for it." The specimen quoted by Mr. Bolton is in the Kay-Shuttleworth Collection in the Manchester Museum, and is labelled as coming from "Coal-measures, Burnley, Lancashire". I doubt very much that it comes from the Coal-measures at all, as the matrix is more like one of the impure Pendleside Limestones. The species is *P. becheri* undoubtedly, and associated with it is an obscure Goniatite.

[1] Q.J.G.S., vol. lxi, pl. xxxv, fig. 3, 1905.
[2] Trans. Manch. Geol. Soc., vol. xxviii, p. 584, 1904.
[3] Q.J.G.S., vol. lxi, p. 535, 1905.
[4] Trans. and Ann. Rep. Manch. Micro. Soc., 1895.

CEPHALOPODA.

Glyphioceras phillipsi, Foord & Crick (?). I have in my possession a small fragment of a *Glyphioceras* from the Marine Band, River Tame, Dukinfield, which suggests reference to this species on account of its ornament. The fragment appears to be pretty close to the aperture, and the test is ornamented with fine striæ, slightly waved on the side, curved forward near the periphery and on the latter forming a deep broad sinus.

Gastrioceras carbonarium (Von Buch). A fragment of a whorl exhibiting the tuberculated umbilical margin is referred to this abundant Lower Coal-measures form. It was obtained by me from the same band as the above-mentioned *Glyphioceras*.

Dimorphoceras gilbertsoni (Phill.) (?). This species appears to be represented in the Ashton Moss Marine Band by several immature examples in a small fragment of rock collected by Mr. R. Cairns.

Pleuronautilus costatus, Hind.[1] Two imperfect Nautiloids from the Marine Band, Ashton Moss Colliery, collected by George Wild, are considered by Dr. Hind to be identical with his species from below the Gin Mine Coal, North Staffordshire Coal-field. One much-crushed specimen is very like his fig. 5*a* of pl. xxxvi[2]; the other is an uncrushed fragment of the body-whorl displaying very clearly the ornamentation of the shell. It would be interesting to know the relation of this species to *Pleuronautilus ratifer* (Salter), recorded from the same Marine Band.[3]

Orthoceras spp. At least two forms of *Orthoceras* occur in the Marine Band at Ashton Moss and Dukinfield, both of which are represented in the Wild, Grundy, and Cairns Collections in the Manchester Museum.

The commonest form would clearly come under Professor de Koninck's[4] division "Orthocerata, 1st Lævia, A. gracilia", as the shell appears to possess a cylindrical siphuncle and a smooth or nearly smooth test. The species somewhat resembles in general form and slenderness the inferior ends of his *Orthoceras calamus* (pl. xxxviii, fig. 6) [= *O. inæquiseptum*, Phill.] and *O. martinianum* (pl. xliv, fig. 4).

A similar form, referred by Dr. Hind to *Orthoceras* aff. *ascicularе*, Brown,[5] is met with in the Marine Band below the Gin Mine Coal, North Staffordshire Coal-field. The identification, however, of the Lancashire and Staffordshire specimens with Brown's species is, in my opinion, very unsafe. The original of his species came from the Pendleside Series, near Todmorden, and formed part of the Gibson Collection. The type-specimen (in the Manchester Museum) has, unfortunately, suffered considerable loss since Brown's time, as it now consists solely of the impression of the original organism on a fragment of black shale. The form, as will be seen by his figure,[6]

[1] Q.J.G.S., vol. lxi, p. 540, pl. xxxvi, figs. 5–5*b*, 1905.
[2] Op. cit.
[3] *Geology of the Country around Oldham* (Mem. Geol. Surv.), 1864, p. 64, pl. i, fig. 6.
[4] *Faune du Calc. Carb. de la Belgique*, 1880, p. 50.
[5] Q.J.G.S., vol. lxi, p. 542, pl. xxxvi, figs. 6, 7, 1905.
[6] Trans. Manch. Geol. Soc., vol. i, pl. vii, fig. 39, 1841.

is a much more slender one than the examples from the Lancashire and Staffordshire Coal-fields.

The second form of *Orthoceras* belongs to Professor de Koninck's division "Orthocerata, 2nd Annulata", as the surface is ornamented with numerous fine concentric rings. It is a much more robust species than the other, recalling *Orthoceras cinctum*, Sow., but the material available is too imperfect for accurate determination.

VI.—Notes on Two Arthropods from the Lancashire Coal-measures.

By J. Wilfrid Jackson, F.G.S.

SOME time ago the Manchester Museum purchased a selection of Coal-measure Fishes from the executors of the late Mr. John Ward, of Longton, and included with these were gutta-percha casts of two species of Arthropods. These were mounted on wooden tablets covered with green paper, one specimen being labelled: "*Limulus trilobitoides*, Buck. (*Bridgewater Treatise*, vol. ii, pl. xlvi, fig. 3). Roof of the Upper Bent Mine, Middle Coal-measures, Hunt Lane, near Oldham. Original in the cabinet of E. W. Binny, Esq." The other: "*Limulus rotundatus*, Prest. Coal-measures, Oldham."

The first-mentioned species (now recognized as *Belinurus lunatus*, Martin, sp.) is recorded by Salter in the Geological Survey memoir, *The Geology of the Country around Oldham* (1864), p. 63, as follows: "*Limulus trilobitoides*, Oldham (Manchester Geological Museum)." Bolton in his "Palæontology of the Lancashire Coal-measures"[1] also repeats this record, and adds: "The original specimen was deposited in the Natural History Museum, Manchester, but has disappeared."

No horizon is given by Salter for this species, nor does it appear to have been recorded since from any Oldham horizon; the fact, therefore, of the cast possessing full details as to precise locality and horizon is of particular interest.

It is much to be regretted that the second species (now recognized as *Prestwichia rotundata*, H. Woodw.) does not possess a like amount of information as to its horizon, etc. It does not, however, seem improbable that it is referable to the same horizon as *Belinurus lunatus*.

VII.—On the Layers of the Molluscan Shell.

By A. R. Horwood (Leicester Museum).

I AM glad that my short article[2] dealing with the occurrence of aragonite in the Middle Lias has evoked some interest. Professor Grenville Cole,[3] who notices (with Mr. O. H. Little) this paper, has evidently delved deep, and I only hope that the publication of

[1] Trans. Manch. Geol. Soc., vol. xxviii, p. 601, 1905.

[2] "On the Occurrence of Aragonite in the Middle Lias of Leicestershire: with some remarks on the calcareous character of the *spinatus* beds": Geol. Mag., 1910, p. 173.

[3] "The Mineral Condition of the Calcium Carbonate in Fossil Shells": ibid., 1911, p. 49.

my preliminary note on aragonite in the Middle Lias has not prematurely precipitated that of his earlier research upon the matter from a more general point of view.

All geologists will be grateful to Professor Cole for giving the world at large so full and well-digested a summary of the chemical side of the question, as well as the result of the tests advocated applied to the shells within his immediate purview (at Dublin) from an extensive range of the geological formations.

The object of these remarks is not to "go one better" than the paper alluded to, but to clarify some misconceptions of my own and others and to set the question upon a firmer and sounder basis for future research.

By the term 'aragonite shells' it would appear that not only have we (1) the shell before fossilization, exhibiting typical aragonite characteristics, but also (2) the presumed former occurrence of it in a fossil shell when the fossil is found to-day as a cast, or (3) replaced by a granular form of calcite. Lastly, we have (4) the known occurrence of certain classes of shells now as aragonite shells in a fossil state.

(1) Dr. Sorby [1] gave a full summary of recent characters of the shell-wall of recent shells, and it has been assumed that this applies to fossil shells as well (though forgotten, as we shall see). The classes he recognized as respectively exhibiting the specific gravity of calcite or aragonite were thus summarized in a paper by Professor P. F. Kendall.[2] They are contrasted here with a table given later—

Calcite.	Aragonite.
Foraminifera.	Corals (but Alcyonaria partly, Hydrozoa mainly aragonite).
Annelids.	Cephalopods.
Echinoderms.	Gasteropods (except *Patella*, *Fusus*, *Littorina*, *Purpura*, etc.).
Polyzoa (containing also some aragonite).	Conchifera (except *Ostrea*, *Pecten*, and outer layer of *Spondylus*, *Pinna*, *Mytilus*).
Brachiopoda.	
Ostrea and *Pecten*.	
Cirripedia and all other Crustacea (the former exhibiting also some aragonite and phosphate of lime, the latter some phosphate).	

(2) Sorby alluded to the occurrence of aragonite shells as *casts* in limestone.[3] But whereas limestones are more usually composed of calcite than aragonite, there are more calcite shells than the latter. In rocks of clastic origin, e.g. the Coralline Crag, casts occur commonly, and the shells belong mainly to the groups whose shell, when the animal was alive, was of aragonite, according to the above scheme. Professor Kendall gave a full list of these.[4] In the paper on the Middle Lias referred to [5] I gave a short list of a few genera which very frequently occur as casts. It is hoped to extend this and other

[1] Presidential Address Geol. Soc., 1879, pp. 29–30, reprint.
[2] Geol. Mag., 1883, p. 497.
[3] Presidential Address Geol. Soc., 1879, p. 35.
[4] Geol. Mag., 1883, p. 498.
[5] Ibid., 1910, p. 175.

details as to the nature of the shell-layer when preserved in specific instances in a later communication. The causes assigned for the occurrence of shells *once possessing an aragonite shell-layer*[1] are recognized by me (ibid., pp. 175, 177) as due to the causes assigned to their decomposition in other beds by Professor Kendall[2]—(*a*) enclosure in permeable beds, (*b*) flow of carbonated water. The latter cause was not alluded to directly by me, but is really an adjunct or necessary outcome of (*a*). Further important remarks on the occurrence of shells once possessing an aragonite shell-layer are given by Professor Kendall and Mr. Cornish in the valuable paper quoted (*antea*). Apparently the term 'aragonite shells' was used by these authors in a wide sense in this paper, for the existence of shells with an aragonite layer in the Coralline Crag is alluded to, and this term probably in the first paper (Geol. Mag., 1883, p. 497) did duty for both. I must plead guilty in my own previous paper to a similar loose terminology (to be corrected *infra*). That Professor Kendall used the term without applying any other distinction than the prefix 'actual' to those still retaining the aragonite test alongside of shells without any present shell-layer (in the rocks) is clear. Possibly the use of the term has been due to the sanction of the term by Sorby, who uses it for recent shells and rather often in his address (Geol. Soc.), whilst he also recognizes the occurrence of these same groups as casts in the rocks and also with the aragonite now converted into calcite.

Moreover, it appears that by the use of the terms 'aragonite Mollusca' and 'aragonite shells' in Lias (p. 54), in Great Oolite (p. 53), and in Cornbrash (p. 51) and Cleveland Ironstone (p. 54), 'calcite organisms' in Oolites (p. 53), 'calcite Mollusca' (p. 52), 'calcite Polyzoa' in Portland Oolite (p. 50), 'aragonite shells' in Purbeck Limestone (p. 49) and Chalk (p. 48), 'calcite shells' in Kentish Rag (p. 49), Sorby intended to convey the idea that they belonged to a type in which to-day the shell is characterized by being composed of either calcite or aragonite. In these passages he says nothing as to their mineral structure at the period cited, which he examined. It appears, indeed, that it has been left to later observers to point out what shells still retain the aragonite layer. But in the following passages the terms are used with accompanying indications of their state at the time of examination (he of course makes *general* statements as to the state of the calcite or aragonite in the fossil state compared with its original structure), viz., under Tertiary limestones he writes: "Being aragonite shells they have usually been removed or changed into crystals of calcite," and as to the Barton Clay, "that of the various Gastropoda, composed of aragonite, is as perfect as in living shells." This surely means that Sorby had in his mind Barton Clay Gasteropods, in which the shell was aragonite originally when the animal was alive, and when he examined it *also*, or unaltered. Surely Professor Cole cannot hesitate to accept this, though he says it is not clear that Sorby meant to assert this. I think this is the clearest passage in which Sorby indicates that the shells he examined were *still* aragonite.

[1] As we shall see, this is the correct way to describe aragonite shells.

[2] Geol. Mag., 1888, p. 68.

And again he wrote (p. 49) "freshwater shells of the aragonite type" in referring to the Wealden limestones, showing that he had in mind their first, not fossil condition.

As to *pre*-Jurassic formations, he writes (p. 56) of the Carboniferous Limestone of "fragments of what were probably aragonite organisms" as "now quite crystalline", and "show no structure", and (p. 57) as to the Devonian limestones "completely disintegrated aragonite organisms", and under Silurian limestones as to the Upper Ludlow rock (p. 60) of "some portions of what were probably aragonite shells", and "few or no fragments of organisms not originally calcite", and in the case of Aymestry Limestone of 'aragonite shells', in connexion with Wenlock Limestone, of "recrystallized fragments of aragonite shells". Thus, as Professor Cole remarks, it is apparently the case that in rocks of pre-Jurassic age we cannot expect shells to consist of aragonite (Geol. Mag., 1911, p. 49).

This use of the terms as applied to mineral states of shells not identical with their original state is to be regretted, and I have therefore (*infra*) drawn up a nomenclature which I hope will prevent any confusion in the future.

Professor Cole, in his *Aids to Practical Geology*, 1902, p. 201, distinguishes shells as 'aragonite shells' and 'calcite shells'. That he deserves the credit for introducing a clearer nomenclature for these various stages is obvious from the attention he has drawn to my own loose use of terms and the present attempt to improve on them. I would say here, however, that the expression "preserved in aragonite" (p. 76 of my paper) should be taken as correct, but that for the words just above, "when preserved as fossils," should be substituted "the recent shells are of", and lower down "if not removed by decomposition". For the list given by Sorby deals with the types of shell in living shells, and the comparison made with fossil types will not hold good all round, since, as pointed out by Dr. Sorby, Professor Cole, and others, the aragonite is often replaced by calcite as a granular pseudomorph. This false parallel has probably caused the artificial division into calcite and aragonite shells, apart from (1) alteration in the shell-substance or (2) possibility of different shell-layers in the same shells.

That I had no real reason for confusing the two classes of shell-structure present and past is illustrated by the passages (ibid., p. 174) "to the parts of shells which have not been converted into calcite", (ibid., p. 175) "all have the outer original aragonite layer removed, and are preserved as casts", and (p. 177) "aragonite as the replacing mineral", but here 'replaced' should be read for 'replacing'. So much by way of correction of slipshod terms, which I am the less unwilling to admit because I am not the sole offender!

(3) When the shell neither exhibits an aragonite layer nor an *original* calcite layer, and is not a mere cast, it may be preserved as a shell with the *original* aragonite layer replaced by calcite of a granular character. Rose, in 1858, suggested that shells found as casts were originally of aragonite, those still preserved of calcite. Sorby further (ibid., p. 35) remarks on the transformation of aragonite into calcite: "when the aragonite shells are still represented by

a distinct calcareous layer, this has no longer the original structure, but is more or less coarsely crystalline, and quite unlike the contiguous calcite shells which still retain their original microscopical and optical characters."

Professor Cole (ibid., p. 50) has referred to the passing of aragonite into calcite in the fossil state, and the record of fossils he gives, where the shell-layer is determined as calcite in the case of those originally possessing an aragonite test, forms the nucleus of our specific enumeration of such cases. In the table here appended additional instances are given.

(4) The occurrence of aragonite in the shell-layer of fossil shells and other organisms is definitely remarked upon by Sorby (ibid., p. 47) in regard to the Barton Clay. Messrs. Kendall and Vaughan Cornish refer to actual aragonite shells (ibid., p. 68) in the Coralline Crag, species of *Fusus* (p. 70), Cephalopoda from the Cretaceous, *Belemnitella*, *Artemis lentiformis*, and in *Eschara* an inner calcite and an outer aragonite layer. They state (p. 72) that "the Mollusca always have the aragonite layer internal". But this is not so, for in *Nautilus* it is external, as in all Ammonites. The aragonite nature of porcellanous Foraminifera is referred to and their absence in certain formations noted, though the other group *Vitrea* occurs, being explained by the supposition that they have disappeared or been obliterated, being represented only as casts, which give no indication of their former existence.

In my paper on the occurrence of aragonite in the Middle Lias I have given instances of aragonite shells still preserving their test unaltered. Further, Professor Cole has collected cases of the occurrence of aragonite shell-layers in fossil shells from Jurassic to Recent times, and he admits the occurrence of these in the Lias, adding (ibid., p. 55) that I "may be justified in expecting some retention of aragonite even in Jurassic strata", though in his opening remarks he asks the question whether they are preserved (evidently meaning now) in aragonite, a question he answers for himself, in other instances affirmatively, *en passant*.

So far we have considered the question, almost exclusively, as though only *one* shell-layer (*either* calcite *or* aragonite) existed in fossil shells, regardless of the admitted existence of more than one layer in both Lamellibranchs and Cephalopods. And though incidentally Messrs. Kendall and Cornish refer to two distinct layers in one shell (*ante*), this is apparently the only gleam of light upon the question in all previous research on the shell-layer of fossil molluscs (I should not omit to say that Bather and Hyatt fully recognized this in writings in reference to structure, apart from fossil preservation). For previously everyone, though admitting (tacitly) the homology between the structure of recent and fossil shells, has ignored the triple or double character of the former in stating conclusions as to the chemical composition of the latter.

In the following table we give a summary of the nature of the shell-layer in the different groups of Mollusca, living and fossil, for comparison, omitting for present purposes those exceptions in both Gasteropoda and Lamellibranchiata in which the shell-layers do not

conform to the usual type, e.g., *Patella*, *Fusus*, *Littorina*, *Purpura* in Gasteropoda, *Ostrea*, *Pecten*, *Chama*, *Spondylus*, *Pinna*, *Mytilus* in Lamellibranchiata.

Group.	Living.	Fossil.
Gasteropoda . .	*Only layer.* Aragonite, with chitinous substance (conchiolin), rarely sulphate of lime.	*Only layer.* Aragonite, usually found as casts, but sometimes as aragonite, sometimes granular calcite.
Lamellibranchiata .	1. Outermost layer dark, horny conchiolin. 2. Outer prismatic calcareous layer of calcite. 3. Inner layer, lamellar porcellanous aragonite.	1. Absent. 2. Calcite. 3. Aragonite, usually pseudo-calcite.
Cephalopoda . .	1. 'Black layer.' 2. Porcellanous laminar aragonite. 3. Nacreous calcite.	1. 'Black layer' (rare). 2. Aragonite. 3. Aragonite.

I am quite aware isolated instances (and even published figures, e.g. Hyatt's) have been given of separate layers in fossil shells, but the prevailing custom has been to treat them as one, and as calcite *or* aragonite, never both. The very names 'aragonite shells', 'calcite shells' show the laxity into which we have fallen. The addition of a nacreous layer in Lamellibranchs and Cephalopods is an argument in favour of their derivation from Gasteropods, and not vice versa.

Since there is some confusion in the use of the terms calcite and aragonite shells applied to fossil shells, I have drawn up below a table of terms and states which may be useful in avoiding the confusion inevitable unless the present state and age are both stated parenthetically with each separate use of either names, and as a name, even if it is a bad one, is better than a parenthesis, we offer the following terminology as a beginning in this direction, incorporating existing ones that are easily intelligible.

Terms.	Layer.	Condition or Age.
Calcite.	Inner.	Living.
Aragonite.	Outer.	,,
Authocalcite.	Inner.	Fossil unaltered.
Mesauthocalcite.	Middle.	,, ,,
Autharagonite.	Outer.	,, ,,
Pseudo-calcite.	,,	Fossil altered.
Mesopseudo-calcite.	Middle.	,, ,,
Atestous cast.	Inner or outer.	Fossil.
'Black layer.'	Third layer.	Living or fossil.
Epidermis or periostracum.	,,	Living (rare in fossil state).

	Genera and Species.	Formation.	Locality.
	Gasteropoda.		
1.	*Pseudomelania turbinata* (Stol.)	Middle Lias	Chipping Warden
2.	,, ,,	,,	Pickwell
3.	,, ,,	,,	Tilton
4.	,, ,,	,,	Pickwell
5.	*Amberleya imbricata* (Sow.)	,,	Grimston
6.	*A. undulata* (Phill.)	,,	Thorpe Satchville
7.	*A.* ,, (Phill.)	Lower Lias	Great Dalby
8.	*A. elegans* (Münst.)	,,	Old Dalby
9.	*A. dunkeri* (Münst.)	,,	Ingarsby
10.	*A. gaudryana* (d'Orb.)	Middle Lias	Tilton
11.	*Turbo latilabrus* (Stol.)	,,	Pickwell
12.	*T. brannoviensis*, Wilson	,,	,,
13.	*Trochus northamptonensis*, Wilson	,,	Tilton
14.	*T. thetis*, Münst.	Lower Lias	Old Dalby
15.	*T.* sp.	Middle Lias	Neville Holt
16.	*T. ariel*, Dum.	,,	Tilton
17.	*T. lineatus*, Moore	,,	Chipping Warden
18.	*T. ziziphinus*, Linn.	Coralline Crag	Ramsholt
19.	*T. subexcavatus*, S. Wood	,,	Orford Castle
20.	*T. adansoni*, Payr.	,,	Sutton
21.	*T. papillosus*, Da Costa	Red Crag	Walton-on-Naze
22.	*Scalaria foliacea*, Sow.	Coralline Crag	Sutton
23.	*S. clathratula*, Tate	,,	,,
24.	*Chemnitzia blainvillei* (Münst.)	Lower Lias	Old Dalby
25.	*C. citherella*, Tate	,,	,,
26.	*C. internodula*, S. Wood	Coralline Crag	Orford Castle
27.	*Solarium plicatum*, Lam.	Barton Beds	Barton
28.	*Capulus sinuosus*	Pliocene	Parma
29.	*Natica labellata*, Lam.	Barton Beds	Barton
30.	*Coplostylus brevis* (Sow.)	Headon Series	Hordwell
31.	*Cerithium ibex*, Tate	Lower Lias	Old Dalby
32.	*C. camertonense*, Moore	,,	,,
33.	*C. liassicum*, Moore	,,	,,
34.	*C. ferreum*, Tate	Middle Lias	Tilton
35.	*C. confusum*, Tate	,,	,,
36.	*C. reticulatum*, Desl.	,,	,,
37.	*C. subscalariforme*, d'Orb.		
38.	*C.* var. *spinicostata*, Wright MS.		
39.	*Turritella trigemmata*, Tate	Lower Lias	Old Dalby
40.	*Actæonina ilminsterensis*, Moore	Middle Lias	Tilton
41.	,, ,,	,,	Chipping Warden
	Lamellibranchiata.		
42.	*Nucula emarginula*	Pliocene	Parma
43.	*N. variabilis*, Sow.	Lower Lias	Old Dalby
44.	*Leda equilatera* (Koch & Dunker)	,,	,,
45.	*L. galathea* (d'Orb.)	,,	Great Dalby
46.	*Cucullæa munsteri*, Ziet.	,,	Leicester

	Layers.			Remarks.
	Inner. (1)	Middle. (2)	Outer. (3)	
1.	Cast			The usual state.
2.	,,			,, ,,
3.	Calcite			The only layer, entirely converted.
4.	,,			The only layer, partly converted.
5.	,,			
6.	,,			Opaque white.
7.	Pyritized			Opaque.
8.	Aragonite			Dull white opaque.
9.	Granular calcite			
10.	,,			Entirely converted.
11.	Cast			And (1) partly calcite.
12.	,,			
13.	Calcite			
14.	Aragonite			
15.	Calcite			Opaque white.
16.	,,			
17.	Cast			
18.	Aragonite			Opaque white.
19.	,,			,,
20.	Calcite			Slightly iridescent.
21.	,,			,, ,,
22.	,,			Yellow, translucent.
23.	,,			,, ,,
24.	Aragonite			With casts also.
25.	,,			(1) Opaque white, but nearly entirely a cast.
26.	Calcite			
27.	,,			Dull opaque, white.
28.	,,			Opaque white.
29.	,,			Dull opaque, reddish-white.
30.	,,			
31.	Aragonite			And (1) a cast.
32.	Aragonite and Calcite			,, ,,
33.	Aragonite			
34.	Calcite			Semi-translucent, white, whole shell.
35.	,,			Semi-translucent, white.
36.	,,			Whole shell translucent.
37.	,,			Whole shell.
38.				
39.	Aragonite			
40.	Granular calcite			And as casts.
41.	Casts	*Remaining outer layer in this group (when fossil)*		
42.	Calcite	Calcite		Yellowish, semi-translucent.
43.	Aragonite			Dull, only layer.
44.	,,			Whitish-yellow.
45.	,,			,,
46.	,,			,,

	Genera and Species.	Formation.	Locality.
47.	*Arca liasina*	Middle Lias	Cheltenham
48.	*A. buckmani*, Rich.	,,	Gloucestershire
49.	*Pectunculus glycimeris* (Linn.)	Red Crag	Butley
50.	*Perna maxillata*	Miocene	Basle
51.	*Inoceramus ventricosus*, Sow.	Middle Lias	Cheltenham
52.	*I. concentricus*, Park.		
53.	*Gryphæa arcuata*, Lam.	Lower Lias	Lincoln
54.	*Lima gigantea* (Sow.)	,,	Barrow-on-Soar
55.	*Amussium lunularis* (Römer)	Middle Lias	Tilton
56.	*Pecten orbicularis*, Sow.	Upper Greensand	Warminster
57.	*Modiola scalprum*, Sow.	Lias	Leicestershire
58.	*Pholadomya konincki*, Nyst.	Thanet Sands	Isle of Thanet
59.	*Cypricardia cucullata* (Münst.)	Middle Lias	Chipping Norton
60.	*Astarte striato-sulcata*, Römer	Lower Lias	Great Dalby
61.	*A. compressa* (Mont.)	Chillesford Beds	Chillesford
62.	*Cyrena cuneiformis* (Sow.)	Woolwich Beds	Charlton
63.	*C. pulchra*, Sow.	Bembridge Beds	Isle of Wight
64.	*C. cordata*, Morris	Woolwich Beds	Charlton
65.	*Cardita sulcata* (Brander)	Barton Beds	Barton Cliff
66.	*Unicardium cardioides*, Phil.	Middle Lias	Cheltenham
67.	*Corbis lamellosa*, Lam.	Tertiary	Gisors
68.	*Cardium edule*, L., var. *umbonatum*	Norwich Crag	Bramerton
69.	*Dosinia lentiformis*, Sow.	Red Crag	Walton
70.	*Venus rugosa*, Flem.	Pliocene	Parma
71.	*V. brongniarti*, Payr.	,,	,,
72.	*Protocardium truncatum*, Sow.	Middle Lias	Chipping Norton
73.	*Cytherea erycinoides*	Calcaire Grossier	Ronca
74.	*Corbula ficus* (Brander)	Barton Beds	Barton
75.	*C. striatula*, Sow.	Gault	Folkestone
76.	*C. pisum*, Sow.	Barton Series	Barton
	Cephalopoda.		
77.	*Nautilus centralis*, Sow.	London Clay	Middlesex
78.	*Baculites ovatus*, Say	Upper Chalk	Dakota
79.	*Scaphites nodosus*, Owen	,,	,,
80.	*Psiloceras planorbe* (Sow.)	Lower Lias	Watchet
81.	*Coroniceras sauzeanum* (d'Orb.)	,,	Glen Magna
82.	*C. bucklandi* (Sow.)	,,	Leicestershire
83.	*Vermiceras conybeari* (Sow.)	,,	Kilby
84.	*Arnioceras semicostatum* (Y. & B.)	,,	Evesham
85.	*Hildoceras bifrons* (Brug.)	Upper Lias	
86.	*Grammoceras serpentinum* (Rein.)	,,	Yorkshire
87.	,, ,,	,,	Lincoln
88.	*Ludwigia cornu* (S. Buckm.)	Interior Oolite	Bradford Abbas
89.	*Paltopleuroceras spinatum* (Brug.)	Middle Lias	Yeovil
90.	*Amaltheus margaritatus*, Montf.	,,	Saltburn

	Layers.			Remarks.
	Inner. (1)	Middle. (2)	Outer. (3)	
47.	Calcite			Whitish-yellow.
48.	Aragonite			
49.	Calcite	Calcite		(2) Dull white.
50.	,,			White.
51.	,,	Calcite		(2) Opaque brown, (1) white.
52.	,,	,,		(1) White, (2) dull red.
53.	,,			Translucent grey.
54.	,,			Dull black.
55.	,,			Translucent white.
56.	Aragonite	Calcite		(1) White, (2) dull brown.
57.	Calcite			Dull brown, translucent.
58.	Aragonite	Calcite		(1) White, (2) dull pinkish-white.
59.	Calcite	,,		(1) Dull white, (2) pinkish-white.
60.	Aragonite			Opaque, dull white.
61.	Calcite			Brownish-yellow.
62.	,,			Opaque white.
63.	,,			
64.	,,			White.
65.	,,			
66.	Aragonite	Calcite		(1) Opaque, dull white, (2) opaque brownish-white.
67.	Calcite			Pure white.
68.	,,	Calcite		(1) White, (2) dull brown opaque.
69.	,,	,,		,, ,, ,,
70.	,,	,,		(1) and (2) pinkish-white.
71.	,,	,,		
72.	,,	,,		(1) and (2) dull brown.
73.	,,			Dull chalky-white.
74.	,,	Calcite		
75.	Aragonite			
76.	Calcite	Calcite		
77.	Calcite	Calcite		(1) Opaque, (2) brown.
78.	,,	,,	Calcite	(1) Translucent brown, thick, (2) thin iridescent, (3) brown translucent, thick.
79.	,,			Iridescent, translucent, aptychus also calcite.
80.	,,	Calcite		(1) Dirty brown, iridescent, (2) white.
81.	,,	,,		(1) Brown, (2) pyritized.
82.	,,	,,		
83.	,,			Dull yellowish-brown, thin, slightly translucent.
84.	,,	Calcite		(1) Translucent, (2) dark brown.
85.	,,	Aragonite		(1) Dark brown, (2) light creamy-brown, opaque.
86.	,,	,,		(1) Pyritized, (2) dark brown.
87.	,,	,,		(1) Pyritized, (2) opaque white, powdery.
88.	,,			Translucent, yellow.
89.	,,			Translucent.
90.	,,	Calcite		(2) Opaque brownish-white.

	Genera and Species.	Formation.	Locality.
91.	*Amaltheus margaritatus* (Montf.)	Middle Lias	Crick
92.	*A. ibex* (Quenst.)	,,	Cheltenham
93.	*Amblycoceras capricornum* (Schloth.)	Lower Lias	Lyme Regis
94.	,, ,,	Glacially derived from Lias	Leicester
95.	*Tropidoceras exaratum* (Y. & B.)	Upper Lias	Stroud
96.	*Acanthopleuroceras valdani* (d'Orb.)	Lower Lias	Old Dalby
97.	*Deroceras armatum* (Sow.)	Middle Lias	Whitby
98.	*D. subplanicosta* (Opp.)	Glacially derived	Leicester
99.	*D. planicosta* (Sow.)	Lower Lias	Robin Hood's Bay
100.	*Dactylioceras commune* (Sow.)	Upper Lias	Whitby
101.	*Perisphinctes triplex* (Sow.)	Kimmeridge Clay	Weymouth
102.	*Hoplites denarius* (Sow.)	Gault	Folkestone
103.	*H. tuberculatus*, Sow.	,,	,,
104.	*Anahoplites splendens* (Sow.)	,,	,,
105.	*Crioceras plicatile* (Phil.)	Neocomian	Speeton
106.	*Hamites maximus*, Sow.	Speeton Clay	Filey
107.	,, ,,	Gault	Folkestone
108.	*H. attenuatus*, Sow.	,,	,,
109.	*Cosmoceras jason* (Rein.)	Oxford Clay	Christian Malford
110.	*Ancyloceras spiniger*um, J. de C. Sow.	Gault	Folkestone
111.	*Belemnites owenii*, Pratt, var. *puzosianus*, d'Orb.	Oxford Clay	Peterborough
112.	*Belemnites* sp.	Lias	Northamptonshire

In order that there may be, further, no need to confuse the nature or composition of the shell-layers of either fossil or recent shells, we give below some of the differences or tests that serve to distinguish the two forms of carbonate of lime in shells.

Character or Test.	Aragonite.	Calcite.
Specific gravity	2·94 to 3	2·72
Hardness	3·5 to 4[1]	3
Lustre	Opaque	Translucent
Composition—		
Carbonic acid	—	42·2
Carbonate of lime	98·02	54·4
Carbonate of strontium	·99	—
Protoxide of iron	—	1·55
Peroxide of iron	·11	—
Silica	—	1·85
Water	·17	—
	100	100
With solution of cobalt nitrate	Turns lilac	No reaction

[1] An aragonite shell will scratch a calcite shell.

	Layers.			Remarks.
	Inner. (1)	Middle. (2)	Outer. (3)	
91.	Calcite			Opaque white.
92.	(?)	Aragonite		,,
93.	Calcite	Calcite		(2) Opaque white.
94.	,,	,,		(2) ,,
95.		,,		(2) ,,
96.	Pyritized	,,		(2) ,,
97.	,,	,,		(2) Opaque pinkish-cream.
98.	,,	,,		(2) Opaque pinkish-white.
99.	,,	,,		(2) ,, ,,
100.	,,	,,		(2) Dark brown, translucent.
101.		,,		Iridescent, opaque, pinkish-white.
102.	Pyritized	,,		(2) Opaque white.
103.	,,	,,		
104.	,,	,,		(2) Pinkish-white.
105.		,,		(2) Opaque white.
106.	Pyritized	,,		(2) Opaque pinkish-white.
107.		,,		Iridescent.
108.	Pyritized	,,		
109.	,,	,,		
110.	,,	,,		
111.	Calcite			
112.	,,	Calcite		Conotheca and phragmocone both calcite, pyritized within.

In order to give some notion of the variability of the structure of the shell-layer in a typical collection of molluscan fossil shells, I have endeavoured to indicate above (pp. 412–17) the characters of the species represented in the palæontological collections in the Invertebrate Department of Leicester Museum arranged biologically.

As this collection exhibits allied genera in proximity, it serves better for this purpose, which is essentially a biological investigation, than a study of the same material arranged stratigraphically. I might have undertaken to examine the shell-layers in the stratigraphical collection, but as its arrangement has only just been completed *pro tem.*, and it requires to make it complete a good deal more material,[1] I have left that till later. The following list, however, contains a representative series of genera, and in some cases species identical with those enumerated by Professor Cole, with varying results. The few cases in which aragonite still remains unaltered are sufficiently rare to warrant the assumption that its preservation is exceptional in Jurassic time, and though of more frequent occurrence in some places in Tertiary time is still less common in the intervening Cretaceous period.

[1] Any geologist who has duplicates may contribute towards this desideratum if he or she will.

Out of a total of 101 species, twenty-four have a shell-layer of aragonite—

Gasteropoda . . .	10 (inner and only layer).
Lamellibranchiata . .	10 (inner of two layers).
Cephalopoda . . .	4 (outer of two layers).
	24

In none of the Cephalopoda recorded above is a third or 'black layer' present, but an example of *Nautilus striatus*, Sow., from the Lias is contained in the same collection possessing this in a very good state of preservation. In *Baculites* an extraordinary thick shell exhibits three distinct layers all of calcite, but the middle one was originally aragonite like other Cephalopods. Of the Cephalopods with an aragonite layer one is a Middle Lias and three are Upper Lias forms. Amongst the Gasteropods which still retain an aragonite layer eight come from the Lower Lias and all but one from the same locality, Old Dalby, whilst two are Coralline Crag species. The proportion of casts in this group is much larger than in Lamellibranchiata or Cephalopoda. There is, moreover, apparently a geographical limit to the persistence of aragonite in the same formation, as illustrated by the Old Dalby species. There is no restriction of it to certain generic types, though it is found most often in the genera *Amberleya*, *Trochus*, *Chemnitzia*, *Cerithium*, and *Turritella*, and amongst these in *Trochus* and *Cerithium* especially, though here allied species are not uniformly preserved as aragonite now.

Amongst Lamellibranchs two species from the Middle Lias are preserved as aragonite; five are from the Lower, and one species of each come from the Upper Greensand, Gault, and Thanet Sands respectively.

In the Lower Lias *Nucula*, *Leda*, *Cucullæa*, and *Arca* in the Middle Lias appear to be especially associated with an aragonite inner layer.

Thus, in the main, the contentions advanced by Professor Cole hold good in a second series of observations made by me independently, whilst my original suggestion as to aragonite being still the shell-layer in Middle Lias forms is borne out by additional examples and further strengthened by the abundance of Lower Lias types.

NOTICES OF MEMOIRS.

The Baluchistan Earthquake of 21st October, 1909. By A. M. Heron, B.Sc., F.G.S. Records, Geological Survey of India, vol. xli, pp. 22–35, 1911.

THE earthquake (of intensity 9, Rossi-Forel scale) occurred at about 5.12 a.m., in a district from 40 to 50 miles to the north of Jacobabad, and resulted in the loss of 231 lives and much damage to the villages of Bagh, Bellpat, and Shahpur. As in most strong earthquakes, the onset of the shock was sudden. Mr. Heron traces three isoseismal lines from the evidence of damaged buildings. They

are remarkable for their great elongation from north-west to south-east, the innermost being 57 miles long and only 8 miles wide. The central area is covered by thick alluvial deposits, but it lies in the gigantic festoon of the Marri and Bugti Hills, by which the north and south trend of the Baluchistan ranges is interrupted. Mr. Heron considers that the earthquake was probably caused by a movement along a reversed fault, although no trace of deep-seated displacement is visible at the surface. C. D.

REVIEWS.

I.—Geology of Thouars.

La Géologie des Environs de Thouars (Deux-Sèvres) et l'Etage Toarcien. By Professor Jules Welsch, of the University, Poitiers. Mém. Soc. des Sc. Nat. des Deux-Sèvres, 1911.

THE rocks of this district include, as a foundation, Pre-Cambrian schists and granitic rocks, and then Toarcian, Bajocian, Bathonian, Callovian, Cenomanian, Turonian, and various Quaternary deposits. Attention is directed especially to the Toarcian of Thouars or *Toarcium*, where the classic section as seen in the quarries at Vrines shows in downward succession: Plateau deposits (1½ metres), Cenomanian (½ metre), Toarcian (conglomerate and grit, blue marls, ferruginous oolites, yellow marls and limestones, about 10 metres), Pre-Cambrian (schists and slates).

The Toarcian strata (as originally grouped by d'Orbigny) are divided into the following zones or palæontological horizons by Professor Welsch:—

Ammonites opalinus (with *Rhynchonellæ cynocephala*, *Terebratula infra-oolithica*, etc.).
A. aalensis (with *Dumortieria Moorei*, etc.).
A. radians (with *Catulloceras dumortieri*, etc.).
A. insignis (with *Grammoceras fallaciosum*, etc.).
A. toarcensis (with *G.* cf. *striatulum*, etc.).
A. variabilis (with *Lytoceras sublineatum*, etc.).
A. bifrons (with *Dactyloceras holandrei*, etc.).
A. falcifer (with *D. annulatum*, etc.).

The conglomerate and grit (1 to 3 metres thick) which rests irregularly on the Pre-Cambrian was at one time grouped with the Middle Lias, but Professor Welsch, after prolonged research, found in the strata an ammonite near to *Harpoceras Strangewaysi*, and he groups the beds with overlying layers in the zone of *Ammonites falcifer*.

He remarks that there is a gradual passage from one zone to another in the Toarcian of Thouars, and that the type of the stage has been well chosen in the quarries of Vrines–Thouars, where there occur neither the Ammonites of the Middle Lias nor those of the Bajocian.

After commenting on the Aalenian division of Mayer-Eymar, Professor Welsch observes that there are affinities between the beds with *Lioceras opalinum* and those with *Ludwigia Murchisonæ*, while again it is difficult to separate the higher zonal stages in the Bajocian, the divisions being arbitrary and local.

II.—Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1910. pp. iv, 87, with 6 text-illustrations. London: printed for H.M. Stationery Office, 1911. Price 1*s*.

DURING the past year the Geological Survey in England and Wales have been engaged in mapping portions of the coal districts of Flintshire, Denbighshire, Warwickshire, and South Staffordshire, and some of the agricultural and residential areas of Berkshire, Buckinghamshire, and Surrey, with the object of completing the six-inch survey of the London district and the south-east of England. In the Welsh district the subdivisions of the Carboniferous rocks have been mapped in detail, and certain red sandstones and marls, formerly grouped as Permian, are now placed with the Upper Coal-measures. A good deal of fresh information regarding the Glacial drifts and newer deposits has been gathered. In Warwickshire and South Staffordshire new information has been obtained on the structure, the faults, and the upper red barren measures of the coal-fields, and an account is given of bands of calcareous concretions in the Keuper Sandstone that resemble conglomerate and have been so described in the record of a boring. The glacial deposits comprise a Western Drift, composed chiefly of Bunter material, and an Eastern Drift, with Chalk flints, etc.

In the account of work done in the London and South-Eastern district there is a new and important record of a deep boring at Ottershaw Park, which has been carried through Bracklesham Beds to a depth of 1,556 feet, the base of the Gault not having been reached. The details are of great interest, inasmuch as after penetrating 40 feet of ordinary Upper Chalk the bore-hole was carried through 211 feet of Eocene clays and sands mixed with chalk and flints, after which solid chalk was again reached. The disturbed beds seem to have been met with along a nearly vertical fissure. The greywethers and Drift on the Chiltern Hills are well known.

In Scotland field-work has been carried on in Mull and South Morvern, in the counties of Sutherland, Perth, and Inverness, and in the central coal-fields. A collection of fossil plants from the Carboniferous rocks, discovered by Professor Judd at Morvern, has been examined by Dr. Kidston, and the species indicate that the strata are of approximately the same age as the productive Coal-measures of Central Scotland. Evidence of Rhætic beds has been found in Morvern, and some account is given of the Lower Lias and Cretaceous rocks of that region. Good progress has been made in mapping the Tertiary igneous rocks of Mull, and it is observed that the Tertiary coals of the island are of little economic value. In the North and Central Highland district the work has been continued among the metamorphic and associated igneous rocks, including the Lewisian and Moine types, but the relations between these have not yet been definitely established. In the Central Coal-field the revision of the Lower and Upper Carboniferous rocks has been carried on in the districts of Shotts, Fauldhouse, Carluke, East Kilbride, and Douglas. Many new facts are recorded, notably the list of fossils from the

Calciferous Sandstone in the East Kilbride district, where a Pendleside fauna, with *Posidonomya Becheri*, *Pterinopecten papyraceus*, and other species, has been discovered.

III.—Swedish Geological Survey.

A Swedish Pre-Glacial River.

IN the recently issued Year Book of the Swedish Geological Survey for 1910, Dr. Nils Olof Holst, under the title "Alnarps-Floden en Svensk 'Cromer-Flod'", publishes an account of a large river of pre-Glacial age, which he believes to have run right across the southern part of Scania in a N.W.–S.E. direction, serving as the outlet for a large part of the southern Baltic and of northern Germany, and thus playing much the same part as the Sound and the Belts do now. This river-bed, which runs not far from the town of Malmö, is filled with thick river deposits and forms a natural water-basin of artesian character. Therefore, for the purposes of Malmö's water supply, the deposits have been pierced by a large number of borings, and, especially of recent years, a large amount of information has been collected concerning them and their included fossils. The paper gives a detailed account of the sections found at different borings, as well as a complete list of fossils. The general conclusion is that the main river deposit is of about the same age as the Cromer forest-bed and a little later than the *Cyprina* clay of northern Germany. These deposits are very rich in amber, which seems to show that the river must have come from the home of amber in the province of East Prussia. In this case it must have flowed over the region where the southern Baltic now is, and that region must then have been in the main dry land. The various changes of level to which the observed phenomena point are thus summarized by Dr. Holst: "The ice period was preceded and introduced by an elevation of the primitive Scandinavian massif, correlated with a depression where the southern Baltic now lies. It was during this depression period that the *Cyprina* clay was deposited. During the next stage, after the inland ice had been piled up in northern Sweden and perhaps also over part of middle Sweden, this ice exercised such a pressure on the primitive massif that the whole region outside of it, that is to say, southern Sweden and northern Germany, was pressed up. This is the Cromer period or the pre-glacial, north European, mainland period. It was then that the pre-glacial rivers hollowed out and filled their beds. Finally, when the inland ice approached the southern Baltic, there took place here a fresh depression, and for a short period an arm of the sea stretched in again right up to East Prussia, to be speedily covered up by the still ever-advancing ice. It was in this gulf that the pre-glacial *Yoldia* clay of Prussia was deposited. In the same way, as the inland ice retreated from the southern Baltic district, there occurred first a depression, the late glacial, corresponding to the previously mentioned pre-glacial; then an elevation, the well-known post-glacial, the mainland period of northern Europe; and finally the last depression, that of the *Litorina* period corresponding to the pre-glacial *Cyprina* clay period." Dr. Holst

believes that the river-beds already discovered indicate a heavy rainfall at the close of the Tertiary era, and that there must have been many such large rivers, whose beds and courses remain to be discovered by the geologists of the future.

IV.—Geological Survey of India.

AN essay on "The Geology of the Andaman Islands, with references to the Nicobars", by Mr. G. H. Tipper (Mem. Geol. Surv. India, vol. xxv, pt. iv, 1911), contains two colour-printed maps of the three islands on the scale of 1 inch to 4 miles. The middle island was not explored, "on account of the wild Jarawa tribe." The formations represented are Upper Cretaceous serpentines, Eocene conglomerates and sandstones, Miocene limestones, shell marls, and Foraminiferal sands, also Miocene (?) beds with Radiolaria, and Recent mangrove swamps. In addition there are some scattered exposures of quartzites, jaspers, and porcellanic limestones of Pre-Tertiary age, in part Lower Cretaceous, and into these the igneous rocks have been intruded. Coal occurs in pockets in the Eocene sandstones; it is of poor quality, and no sign of a continuous seam has been observed.

In the Records of the Geological Survey, vol. xli, pts. i and ii, 1911, there are accounts of deposits of manganese-ore in the Central Provinces and in Bengal, by Mr. L. L. Fermor; of the Baluchistan earthquake of October 21, 1909, by Mr. A. M. Heron; and of observations in Kashmir, by Mr. C. S. Middlemiss. There are also descriptions, accompanied by two plates, of Devonian fossils from Chitral, Persia, Afghanistan, and the Himalayas, by Mr. F. R. Cowper Reed. In the General Report of the Geological Survey of India, Mr. H. H. Hayden, Director, gives particulars of the work done during 1910, and records the unusually heavy losses caused by the retirement on October 29 of Mr. T. D. La Touche and on November 30 of Sir Thomas H. Holland, the Director.

V.—La Face de la Terre (Das Antlitz der Erde). Par Ed. Suess. Traduit avec l'autorisation de l'auteur et annoté sous la direction de Emmanuel de Margerie. Tome iii, 2e partie. 8vo; pp. xii, 531–956. Avec 2 cartes en couleur et 124 figures dont 101 nouvelles (89 exécutées spécialement pour l'édition française). Paris, 1911. 12 fr.

WE have already called attention to the English edition of this work, and the present volume contains the text of the first seven chapters of the English vol. iv (noticed in Geol. Mag., April, 1910, p. 178). The French edition, as indicated in the title, contains many additional illustrations, and it has the advantage also of additional references, some of them to works published this year, and the titles are properly inserted between brackets. In the work of translation M. de Margerie has been assisted by MM. Henri Baulig, Paul Lemoine, and Ch. Jacob.

VI.—Pebbles. By E. J. Dunn. 8vo; pp. 122, 76 plates, containing 250 figures. Melbourne, etc.: Robertson & Co., 1911.

SIR ARCHIBALD GEIKIE, in his shilling Primer of Geology, told the story of a Pebble in perhaps the simplest and clearest language that was possible. Mr. Dunn has amplified this story and told us pretty well all that there is to know about the subject. And his many excellent illustrations range from ordinary pebbles in all their stages to wind-worn stones, impressed pebbles, crushed pebbles, obsidian buttons, and ice-scratched stones. His book has nine pages of double-column index and twenty-six pages of description of plates. It is divided into seven chapters, as follows: Miscellaneous, Forms of Pebbles, Material of Pebbles, Formation of Pebbles, Varieties of Pebbles, Transport of Pebbles, and Uses of Pebbles to Man. Of these chapters we give the heads of chapter iv as illustrative of the treatment:—The Formation of Pebbles.—Mechanical Agencies: Heat and Cold—Wind—Water—Ice—Volcanic Action—Earth Movements. Organic Agencies. Chemical Agencies: Reactions between Rock-forming Minerals — Australites. Plant Agencies. Animal Agencies.

Among the more curious notes in the book are those on Australites, which he says are often water-worn or wind-worn into true pebbles, although their origin is clearly volcanic; and the little piles of stones which seem to be properly recognized as gizzard-stones of dead Moas. In this latter connexion the interesting paper by Mr. W. H. Wickes on Stomach Stones, and the more recent note on a find of a pile of stones said to have come from an elephant, would have been too recently published for inclusion in Mr. Dunn's book. We note a certain amount of repetition which Mr. Dunn would do well to avoid in another edition, and the omission of a Bibliography which would have been of great use to those interested in a side issue of this kind. The book is dedicated to Professor J. W. Judd. The price is not stated.

VII.—The Chief Geological Zones and their Mollusca. By R. Bullen Newton. Being Presidential Address to the Malacological Society, February, 1911.

THE subject of this address was chosen with a view of placing before the student of recent Mollusca one of the many important applications of the Mollusca found fossil as indexes to the age of the sedimentary rocks and consequent division of those rocks into zones. It is intended as a handy reference paper, includes an abridged table of the stratified rocks, and deals mainly with the Mesozoic beds. The paper is historical in arrangement, and the work of each successive man is easily ascertainable. In his abridged table Mr. Newton gives the chronological terms in general use and the equivalent British formations. As Dr. Marr indicated in his address to the Geological Society (1905), we require three groupings—(1) the formations more or less local, (2) the broad chronological divisions, and (3) the zones. That "Zones are belts of strata, each of which is characterized by an assemblage of organic remains of which one abundant and characteristic

form is chosen as an index", may to a certain extent be conceded; but it must always be remembered that zones are not based on the fauna of a lithological division or formation; they are established by careful collecting of fossils stage by stage, and the zonal subdivisions ultimately adopted may or may not correspond with the lithological or purely stratigraphic divisions. As Dr. Rowe remarked in reference to Chalk zones, he "pins his faith to Zoology, and to Zoology alone", while at the same time he called attention to instances where the lithological and zoological boundaries happened to coincide. We are glad to see the term Bathonian restricted to the Great Oolite Series.

VIII.—Tables for the Determination of Minerals by means of their Physical Properties, Occurrences, and Associates. By Edward Henry Kraus, Ph.D., and Walter Fred Hunt, A.M. 8vo; pp. 254. New York and London: McGraw-Hill Book Company, 1911. Price $2 (8*s.* 6*d.*) net, post paid.

THIS set of tables is framed for the ready determination of 250 mineral species, on the basis of easily recognizable physical properties. Lustre and colour are the chief *fundamenta divisionis*; streak, hardness, and specific gravity being among the other characters tabulated. The tables are in two parts, according as the lustre is metallic or non-metallic; and colour is made an important basis, although for purposes of classification it is far from definite, and in the present work leads to much repetition.

The Introduction comprises a brief sketch of the physical properties of minerals, sufficient, possibly, to enable persons with a small amount of technical knowledge to handle the book with advantage. A glossary follows, and although this is delightfully brief and on the whole adequate, it might be improved by the excision of some terms and more attention to the connotation of others. The word 'waxy', for example, is given in the column describing lustre, and on referring to the glossary we learn that 'waxy' means "luster of wax". 'Interlaced,' we are told, means "intertwined, confused"; while 'refraction, double' is defined as "yielding two refracted rays", a definition that might well be objected to as logically inadequate.

Three kinds of type are used for the names of various species, and this feature is designed to indicate their comparative importance, and also to enable the book to be used by students of different grades. In this connexion it might be noted that the rarer felspar anorthite is given more prominence than labradorite. The authors have paid special attention to the associates and modes of occurrence of the minerals with which they deal, and valuable observations are to be found in the column relating to these features; but in the case of cassiterite there is no mention of chlorite as one of its important accompaniments.

The information is arranged as conveniently as possible, and opposite each name references are given to the well-known manuals of Kraus, Dana, and Moses & Parsons. The book is singularly free from typographical errors, though the spelling of 'sanidine' (p. 238) seems to have escaped revision. These tables evidence great care as

regards detail, and being the result of wide experience, both in laboratory and field, should be of great value in the hands of students, teachers, and practical workers.

IX.—Brief Notices.

1. Canadian Rockies.—The *National Geographic Magazine* for June, 1911, is full of geological interest concerning the Canadian Rockies. Mr. C. D. Walcott gives a short sketch of the geology, refers to the Crustacean fauna of the Cambrian, figuring that remarkable Eurypterid *Sidneyia inexpectans*, and illustrating his notes with a beautiful series of photographs of Mounts Schaffer, Robson, Wapta, Huber, and President. Besides these we have a "Panoramic view from the west side of Burgess Pass, 3,280 feet above Field, British Columbia", which includes all the great peaks. This forms a folding plate 8 ft. 6 in. long, and is a fine effort of photography, reproduction, and printing by the Matthews-Northrup Works of Buffalo. It was taken by a Cirkut camera with a revolving bed, by a Bausch and Lomb Zeiss Protar, series vii, with an exposure of one-tenth of a second over each part of the film, and is well worth the attention of any photographer.

Other interesting matter in this number are papers on the glaciers of Alaska and Mount McKinley. We do not know any finer publication for scenery than this magazine, which is the official organ of the National Geographic Society of Washington, D.C.

2. Albania.—Of similar nature, though more scientific in character, is Franz Baron Nopesa's paper on the stratigraphy and tectonics of the Scutari area in North Albania. The author deals mainly with the geology, which ranges from Palæocene to Trias, but illustrates his remarks on the tectonics with a series of fine photographic reproductions and a clear map. The paper appeared in the *Jahrbuch der k.k. Geol. Reichsanstalt*, Vienna, vol. lxi, 1911.

3. Tertiary of Japan.—Dr. Matajiro, Yokohama, has described the Tertiary fauna and flora brought up in borings 240–842 feet from Manoa in the Miike Coal-field. The forms belong to the Palæocene or Eocene of Europe, and include well-known forms like *Phaladomya margaritacea* (Sow.), *Aturia ziczac* (Sow.), and *Lamna* (cf.) *cuspidata*, Ag. There are also a crab, a Cycad, and a Pentacrinid. The paper, with three plates, appeared in Journal Coll. Sci. Tokyo, February, 1911.

4. Minerals in Dust.—Dr. W. N. Hartley (Proc. Roy. Soc., ser. A, vol. lxxxv, June, 1911) has "during the past twelve months" had occasion to ascertain the nature of the mineral constituents of an ordinary turbid atmosphere in Dublin. By means of a small portable quartz spectrograph several series of spark spectra were photographed with graduated exposures of 1, 5, 10, 20, 40, and 60 seconds, all on the same plate. The electrodes in the first series were cadmium, iron, nickel, and copper, a self-induction coil being interposed to eliminate the air-spectrum and the short metallic lines. Thirteen minerals were recognized, and "as no atmosphere is free from dust, and that of cities is particularly dusty, these mineral constituents must be regarded as possible reagents in cases where there is evidence that very minute quantities of basic substances can initiate chemical

reactions and isodynamic changes, such as have generally been considered as spontaneous, and in all cases where a solution in contact with air is liable to be affected".

5. Palæontology at Shepherds Bush.—In the *Museums Journal* for May Dr. Bather describes and comments on "The Palæontology Exhibit at the White City, 1910 and 1911". Exhibits of modern British palæontology were organized by him in connexion with the Franco-British, Japan-British, and Coronation Exhibitions. The first illustrated methods of research, and the last two aimed at showing the scientific results obtained by those methods, especially such as could be obtained only by palæontology. By concrete illustration, the exhibit attempts to embody abstract philosophical ideas. Among the subjects thus elucidated are the restoration of extinct animals, the relations of extinct faunas and floras to those now living, variation in space compared with mutation in time, evolution of single lines of descent, recapitulation and rejuvenescence in individuals and in colonies. Among those to whose assistance Dr. Bather gratefully refers are Dr. C. W. Andrews, Rev. H. N. Hutchinson, Mr. G. C. Crick, Dr. Lewis Moysey, Mr. and Mrs. Clement Reid, Mr. G. E. Dibley, the Bristol Museum, Dr. A. Wilmore, Mr. R. G. Carruthers, Mr. C. P. Chatwin, Mr. T. H. Withers, Mr. H. L. Hawkins, Mr. W. K. Spencer, and Mr. W. D. Lang.

6. Sutherlandshire Gold.—We learn from *Nature* (July 13) that a new attempt is being made to work the alluvial goldfield in Helmsdale, in Eastern Sutherland. The existence of gold there has long been known, and some of the gold of the ancient ornaments found in North-Eastern Scotland may have come from that district as suggested by the Rev. J. M. Joass. The first modern attempt to work the field was during the years 1868 and 1869, when gold was obtained in the Kildonan and Suisgill Burns, two tributaries of the Ullie, the main stream of Helmsdale. Royalty was paid on about £3,000 of gold, but the amount obtained is said to have been considerably higher. According to Dr. Lauder Lindsay (quoted by Dr. J. Malcolm Maclaren) gold of the value of £15,000 was obtained from Sutherland in 1869. The largest nugget was found in the Kildonan Burn, and weighed 2 oz. 17 dwt. The richest alluvial deposits were in the Suisgill Burn, a higher tributary of the Ullie. This burn flows over mica-schists belonging to the Moine system, which have been invaded by granite dykes. The existence of gold in this granite was recorded by Bryce in 1870. The workings were stopped at the end of 1869 owing to damage done to the fishing and the farmers. A serious effort to reopen the field is now being made by the Duke of Sutherland. Gold is being obtained, but whether it occurs in paying quantities has still to be proved. Particulars of the geology of the district will be found in papers by Joass, Quart. Journ. Geol. Soc., xxv, p. 314, 1869; E. Greenly, Trans. Edin. Geol. Soc., vii, p. 100, 1895; and Maclaren, Trans. Inst. Mining Engineers, xxv, 1903.

7. South African Journal of Science.—In No. 6, vol. vii, 1911, Professor P. D. Hahn calls attention to the occurrence of a geyser in the Zambesi Valley, about 2 miles south of the river near Fulunka's Kraal, and 40 miles downstream from the confluence with the Gwai.

Information gathered on the spot by Mr. C. L. Carbutt indicates that the water, which is slightly below boiling-point, is emitted continuously. Mr. J. A. H. Armstrong contributes an account of certain rocks of Archæan age in Natal; they include gneiss, granite, and quartz-diorite.

8. Denudation and Corrosion.—Professor J. W. Gregory discusses the application of certain terms the use of which has become ambiguous (*Geograph. Journ.*, February, 1911). He suggests that *Denudation* be used for the wearing down of the land by any agency; *Erosion* for the lowering of the land by various subaërial agencies, including rivers and glaciers acting laterally; *Abrasion* for the destruction by sea; and *Corrosion* for the excavation by rivers and glaciers of their beds. He rightly dismisses *Corrasion* as a synonym of *Corrosion*.

9. The Glenboig Fireclay.—This fireclay, which is obtained from the Millstone Grit Series near Coatbridge, Lanarkshire, and is said to yield fire-bricks of unequalled quality, has been studied by Professor J. W. Gregory (Proc. Roy. Soc. Edin., vol. xxx, pt. iv, 1910). He finds that its clay-substance is an amorphous hydrous bisilicate of alumina, and may be regarded as the mineral halloysite; that the fireclay was a lagoon deposit, and that it contains zonal, lenticular, and rhombohedral crystals of sideroplesite, which formed in the water and on the floor of the lagoon.

10. Flint Implements of North Cornwall.—Mr. H. Dewey (Trans. Roy. Geol. Soc. Cornwall, vol. xiii, pt. vii, 1911) describes and figures some well-formed flint-flakes from the district of St. Clether and St. Tudy. The productive localities are situated on high land, often near ancient encampments, and their local abundance in St. Clether is suggestive of a manufactory of implements. It is considered unlikely that the material was obtained from any of the ancient or modern beaches, but that it was probably brought from the gravels of Haldon in Devonshire.

11. Arthur's Seat Volcano.—A description of this ancient volcano, by Dr. B. N. Peach, has been reprinted, with slight alterations, from the memoir on the Geology of the Neighbourhood of Edinburgh (noticed in Geol. Mag., March, 1911, p. 133), and has been issued by the Geological Survey, 1911, price 6*d*. It is accompanied by a coloured geological map on the scale of 6 inches to a mile, and by four text illustrations.

12. Miocene Mammals from Nebraska.—In the Annals of the Carnegie Museum (vol. vii, No. 2, 1911) Mr. O. A. Peterson describes (1) a mounted skeleton of *Stenomylus Hitchcocki*, a small aberrant camel, the first remains of which were discovered a few years ago. There have since been found in the Lower Harrison Beds more complete remains of this genus than of any other Miocene mammal. They were obtained by Dr. F. B. Loomis in a hill of closely packed and finely grained sand, about 60 feet thick, overlain by bedded sandstone, in the Niobrara Valley, Sioux County. The excavation is known as the Stenomylus quarry, and a plan is given showing the position of seventeen skeletons and other less complete remains in an area of about 75 by 20 feet. Mr. Peterson also describes (2) a new camel, *Oxydactylus longirostris*, from the same formation at Whistle

Creek, Sioux County, and (3) a mounted skeleton of *Diceratherium Cooki*, a form allied to Rhinoceros, from the Agate Spring Fossil quarries, also in Sioux County.

13. Underground Water Papers.—The United States Geological Survey have issued (as Water Supply Paper No. 258, 1911) a series of short papers relating to investigations of special underground water problems. Among the subjects we may mention that of Drainage by Wells, and the advantages, and possible disadvantages through pollution of water-supplies, are discussed; also the Freezing of Wells; and the Occurrence and Composition of Well-waters in Granites, concerning which it is stated that 87 per cent. of the wells drilled in granite in New England, of which records are available, were successful enough for ordinary domestic use. Most of these were from 50 to 100 feet deep. Another article on Magnetic Wells is of interest, as the phenomena are reported to "consist in the magnetization of needles, knife blades, nails, etc., immersed in the water, both at the source and at a distance, and in the deflection of the magnetic needle in its vicinity". It is well known that magnetism is exhibited by well-casings, and it is concluded "that the phenomena are induced by earth magnetism aided by the vibration of the drill or of the casing when it is sunk by percussion, which permits the readjustment of the polarized particles of the steel". Other articles deal with mineral springs, saline artesian waters, the protection of shallow wells in sandy deposits, etc. Water Supply Paper No. 257, 1911, consists of an essay on Well-drilling Methods, by Mr. Isaiah Bowman.

14. Geology of Melbourne.—A handy little book has been written on this subject by Mr. G. B. Pritchard (Melbourne, 1910, pp. 187, with 44 illustrations). The author's object is to encourage interest in the local geological features and to preserve records of those which are being gradually obliterated by the growth of the city. After an introduction, and short chapters on geological time and on fossils, the author conducts his readers on a series of rambles in and around Melbourne, and in the course of these he describes the local geology and also explains the method of construction of geological maps and sections.

15. Cambridge County Geographies.—Since our former notice of these publications, which are issued by the Cambridge University Press, price 1*s.* 6*d.* each (Geol. Mag., May, 1911, p. 232), we have received the volumes on Aberdeenshire by Mr. Alexander Mackie, on Huntingdonshire by the Rev. W. M. Noble, and on Worcestershire by Mr. Leonard J. Wills. The volumes are full of interesting matter and are well illustrated, Aberdeenshire naturally affording fine views of rock and mountain scenery as well as of granite works. It should be mentioned that relics of Pliocene, as well as Cretaceous and Jurassic formations, occur in the Glacial Drifts of that county. The Fens and their drainage receive attention in the volume on Huntingdonshire, and there is a view of a cornfield on the site of Whittlesey Mere. The volume on Worcestershire contains views of the Malvern scenery, but in this and in the volume on Huntingdonshire space is unnecessarily occupied by full tables of strata and general remarks on geology.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

June 13, 1911.—Professor W. J. Lewis, F.R.S., President, in the Chair.

G. S. Blake: On Zirkelite from Ceylon. The results of five analyses made on fragments grouped together according to their specific gravity, which ranged from 5·2 to 4·4, showed remarkable variation in the percentage composition, the densest containing about 20 per cent. thoria and little uranium, and the lightest 14 per cent. U_3O_8 and little thorium; the precise formula is uncertain. A few crystals, some simple and some twinned, were met with; they apparently belong to the hexagonal system ($\alpha r = 53° 22'$), the observed forms being c (0001), m ($10\bar{1}0$), r ($10\bar{1}1$), s ($20\bar{2}1$), b ($10\bar{1}2$), e (2023), and r the plane of twinning; they were opaque in mass, but translucent and isotropic in splinters.—Rev. Mark Fletcher: Note on some Crystals of Artificial Gypsum. The crystals, which were formed in the condensing plant of a distillery at Burton-on-Trent, were twinned about 101, and the forms 100, 110, 230, 111 were observed.—L. J. Spencer: The larger Diamonds of South Africa. Historical notes relative to the 'Excelsior', 'Jubilee', and 'Imperial' diamonds were given, together with a tabular statement of the weights of the rough and cut stones in carats and grams, and the percentage yield of the cut brilliants from the rough.—F. H. Butler: Brecciation in Mineral Veins. In vein-breccias due to fracture in situ (crush-breccias) replacement of country rock is a characteristic feature. Where the coarse fragments in a brecciated fissure-vein indicate erosion, removal of fine rock-debris may be inferred. Fragments that are angular and uneroded and completely isolated by encrusting material often indicate by shape and position their former existence as a single mass. The quiet removal of such fragments into a vein-cavity after reunion, and also the banding, with concomitant contortion of adjoining soft country rock, by their cement-substance, may be ascribed to the hydrostatic pressure and the solvent and mineralizing properties of the waters which furnished that substance. The coarse constituents of breccia may have been crushed in situ, or forced from fissure-walls by earth-movements, or detached therefrom by aqueous pressure and solution.—Arthur Russell: Prehnite from the Lizard District. Two distinct types of crystals, tabular and prismatic, were recently found by him on hornblende-schist at Pare Bean Cove, Mullion, Cornwall, the former showing the forms 001, 302, 061, and the latter 100, 001, 110, 061, and the rare form 301.

CORRESPONDENCE.

DREIKANTER.

Sir,—I am much indebted to Dr. Bather for pointing out, in your June issue, that when I wrote 'a dreikanter' I really meant 'a Dreikante'. As a matter of fact I meant precisely what I wrote,

and still adhere to it, though I certainly should have written 'Zeuge' and 'Zeugen'. I wrote 'dreikanter' because it was the form used by your reviewer, and should certainly not have used 'Dreikante', as this form does not appear in the only German work[1] dealing with the subject that was available to me for reference. No doubt Dr. Bather has excellent grounds for the use of the form 'Dreikante', and so perhaps my authority was mistaken in his use of 'Dreikanter' in a German work presumably written for Germans.

His letter suggests the question of how far it is necessary to adhere to the original terminations for borrowed words when they fall into common use in English writings. It does not appear to be a great sin to drop them, while it would be intolerable to adhere to them in every case, and I am glad to find the form 'horsts' in the textbook reviewed.

After suggesting that we should be careful to avoid the use of foreign words through laziness or ignorance of our language and defining the qualities that a technical term should possess, Dr. Bather goes on to point out that wind-wearing is not implied by the word 'Dreikante', which, he says, means a tripyramidal or triquetral pebble, and that wind-worn stones of this shape are in a minority. 'Dreikante' implies three-edged and certainly might be rendered by 'triquetral'. Tripyramidal, however, is not such a happy suggestion. Dr. Evans, in a subsequent letter, speaks of the "tetrahedral or tripyramidal form", so we have two authorities each using the same term for something different. It may be suggested that, even if a tripyramid is a possible figure, it must have more than three edges, while it would be more correct to regard a tetrahedron as a tetrapyramid, since any of its four faces can be considered as the base of a pyramid formed of the other three. No doubt the idea Dr. Bather desired to convey by 'tripyramidal' was a closed form bounded by three curved faces, any one of which may be regarded as the base of a pyramid whose apex is the summit of the curved edge in which the two other faces meet. Such a figure is probably more correctly described as a trigonal bipyramid with curved faces.

The term 'Dreikanter', though it does not literally imply wind-action, probably suggests the most typical form of a wind-worn pebble, and has gained wide acceptance in this particular sense, whether the form is only in the process of achievement or whether it has been modified by the formation of other facets.

I have not yet seen dreikanters in the Sudan, nor had the opportunity of studying their formation elsewhere. The object of my former letter was to point out that the phrase suggested as an alternative by your reviewer did not mean the same thing, and, though Dr. Bather admits the truth of this, I regret that his letter gives the impression that he attaches more importance to the correctness of the terminations than to the sense of the word. Doubtless this is not the impression he desired to convey.

G. W. Grabham.

Madeira.
July 10, 1911.

[1] Walther, *Denudation in der Wüste*.

OBITUARY.

ALFRED ELIS TÖRNEBOHM, Ph.D.

Born October 16, 1838. Died April 21, 1911.

We regret to record the death, at the age of 72, of Dr. A. E. Törnebohm, who was Professor of Mineralogy at the Technical College at Stockholm from 1878 to 1897, and Director of the Geological Survey of Sweden from 1897 to 1906. He was elected a Foreign Correspondent of the Geological Society of London in 1910. He was author of papers on the Silurian and older rocks of Sweden, and on the Glacial phenomena of Sweden, Norway, and North Germany. He regarded the Swedish rock-basins as due to disturbances during the Glacial Period. Dr. Törnebohm gave special attention to the iron-ores of Sweden, and published nine maps of the principal districts where they occur (1879–82). He also published a series of microscopical rock studies, with descriptions of the rhomb-porphyry and many other rocks, his later work, apart from his Geological Survey publications, being mainly petrographical. He was author of *Grunddragen af Sveriges geologi*, 1884, of which a third edition was published in 1901; and of *Die Petrographie des Portland Cements*, 1897.

MISCELLANEOUS.

A Palæontologist for the Geological Survey and Department of Mines, New Zealand.

It is now thirty-six years ago since Dr. (afterwards) Sir James Hector came to England on a visit from New Zealand, where he was at that time Director of the Geological Survey. He brought over a number of fossils to the British Museum with the intention of having them described, a task which the late Mr. Robert Etheridge, F.R.S., undertook, but, alas! did not accomplish owing to the pressure of Survey work here.

I remember describing and figuring a new fossil crab, *Harpactocarcinus tumidus*, from the passage-beds, Ototara Series, Woodpecker Bay, South Island, New Zealand, to which Dr. Hector kindly added a Note on the Geology with a section from the Alps to Brighton, New Zealand, and a table of formations (see Quart. Journ. Geol. Soc. London, vol. xxxii, pp. 51–6, pl. vii, 1876). I was since kindly invited by the late Captain F. W. Hutton to contribute some further notes upon New Zealand Crustacea, but regret to say they still remain unwritten.

It is with extreme pleasure that I learn the Geological Survey of New Zealand have at length decided to appoint a palæontologist. This seems to be the outcome of representations made by the Australasian Association for the Advancement of Science, recommended also by Mr. A. Hamilton, Director of the Dominion Museum; and Mr. P. G. Morgan, the new Director of the Geological Survey (who has been appointed in succession to Dr. Bell), has no doubt added weight to these recommendations.